# SCIENTIFIC AMERICAN

No. SUPPLEMENT 297

Scientific American Supplement, Vol. XII., No. 297. Scientific American, established 1845. NEW YORK, SEPTEMBER 10, 1881. Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.


## IMPROVED BREECH-LOADING GUNS.

We give a few illustrations of designs from the Elswick Ordnance Works. We will commence with the breech-closing arrangement now in use, as exemplified by the 43-ton gun. The breech-closing arrangement, which is common to many guns with slight modification, may be taken first, the gun itself being afterwards taken on its own merits.

It differs chiefly from Palliser and French breech-loading arrangements in the system of obturation or closing the joint. Fig. 6 shows the breech end of a charged gun. S is the powder charge with central tube, R; A the steel obturating cup, which fits closely into the mouth of the powder chamber inside the copper breech bush, O O, being fixed on to the breech block by the screw spindle, C. The face of the breech block is slightly convex, so as to leave the surface of the obturating cup gradually toward the circumference of the disk —*vide* Fig. 6. On firing, the pressure of the gas forces the obturating cup against it, at the same time tightly closing the joint between the edge of the cup, A, and O. The fitting of A is, in fact, a most important matter. The firing arrangement consists of a needle, E, and the primer, L, which are carried in a steel cylinder, B, which has an interrupted screw so as to admit of being very quickly entered and tightened. The needle is held back by a spiral spring, G, until struck by a lever hammer, H, which is raised to full cock and made to fall by the pull of a lanyard attached to the shorter arm, U, and the needle then drives its point into the primer, firing the gun. The slide bar guard, K, prevents this taking place when the breech is not home. The stud, T, moving in the groove, Q, holds the slide-bar end sufficiently far in over the vent to prevent the hammer striking the end of the needle until the stud reaches the portion, V, which carries it sufficiently far out to cause the bar to be drawn clear of the vent. The carrier, N, with its catch, P, resembles closely that on similar guns.

The gun itself is shown in section in Fig. 7.

To pass on to another 43-ton gun. In Fig. 9 is shown one strengthened with coils of steel ribbon. The whole of the gun from breech to trunnion-hoop is made of steel; the portions which are made of wrought iron or steel ribbon are so marked in section, the unmarked parts being steel. We have used the word "trunnion hoop" to describe the part known to artillerymen by that name. This gun, however, has no trunnions, being held in a saddle by the square cut rings shown on the lower surface. This gun is a much larger one than those of which we have just been speaking—the bore is 13 in. against 12 in. diameter. 13-in. and 12-in. projectiles of similar proportions, fired with the same velocity, would have stored up work in the proportion of five to four, roughly speaking.

The details as to charges, projectiles, and velocity have not yet been worked out practically, but the following is an approximate estimate. The 12-in. gun, with a charge of from 315 lb. to 325 lb., and a projectile of 700 lb., will have a muzzle velocity of from 1,950 ft. to 1,970 ft., implying an energy of about 18,650 foot tons. The 13-in. gun, with a 500 lb. charge and a 1,000 lb. projectile, may attain an initial velocity not far short of 2,000 ft. per second, having about 27,460 foot tons stored up energy. Such results would argue greater proportional power for the 13-in. gun than the 12-in., and far exceed the estimate made in France that steel wire bears to solid steel in the same quantity strength in the proportion of four to three.

As to proportions, the ribbon 13-in. gun has a length of bore of 390, or 30 calibers, against about 312, or 26 calibers length in the 12-in. gun. The chamber of the former is 8 calibers long against about 7½ in the latter. As to the arrangement of the ribbon coil, it will be seen that it is only carried out to a certain extent; there is no longitudinal application of ribbon in this gun.

The 100-ton guns, muzzle and breech loading, made for the Italian Government for the vessels Duilio, Dandolo, Italia, and Lepanto, and all their working machinery, form an undertaking of such magnitude that it would appear strange to avoid all reference to it. The first guns made in 1875 still remain the most powerful pieces in the world, with the exception of their 100-ton successors of rather larger caliber, made also at Elswick.—*The Engineer.*

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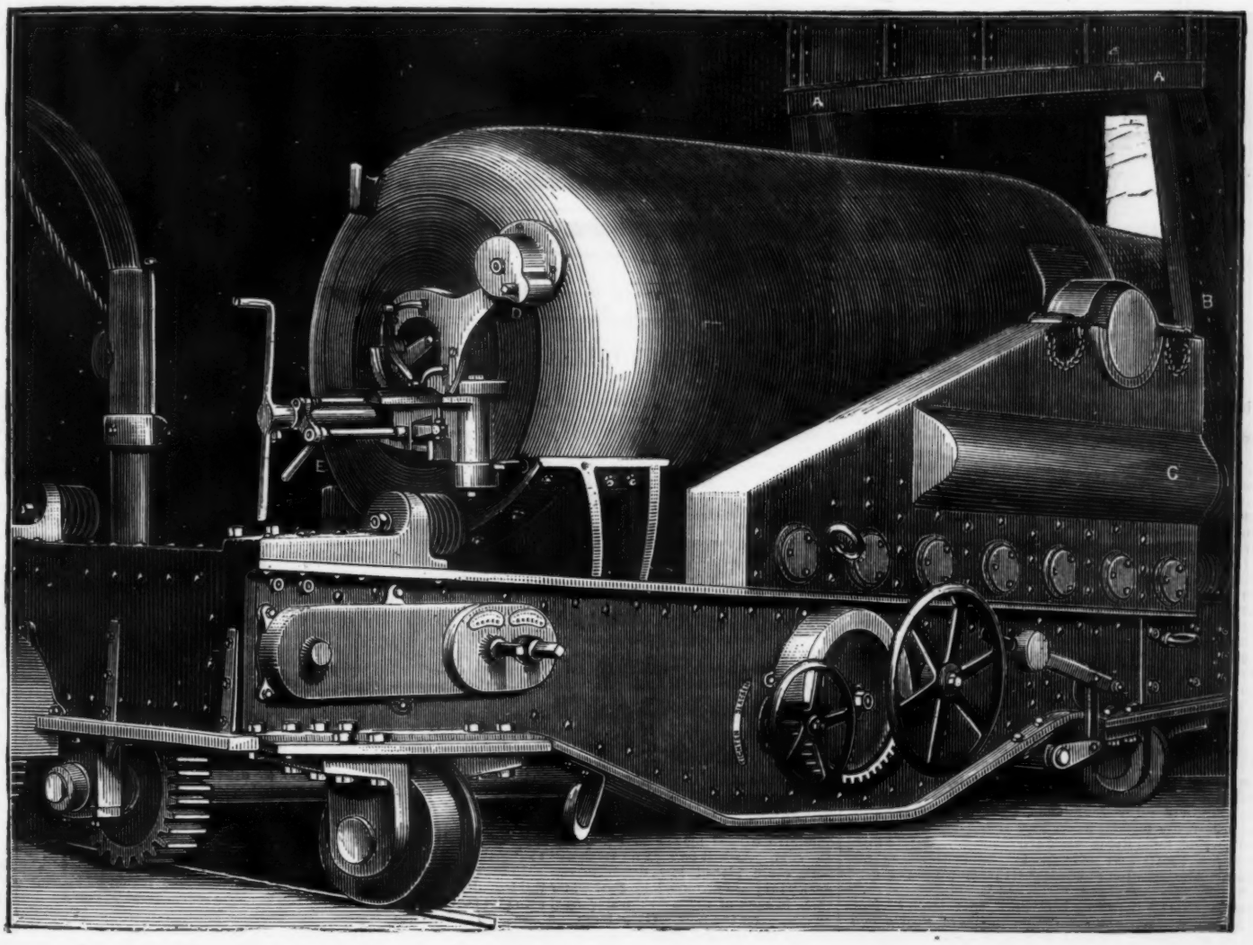
THE HEAT OF EXPLOSIVES.—When, say MM. Sarrau and Vielle, an explosive is decomposed, the heat liberated is equal to the exact excess of the heat of formation of the products over the heat of formation of the explosive.

## THE TORPEDO RAM POLYPHEMUS.

We have described the chief elements of the construction of the Polyphemus, recently launched at Chatham, and discussed some of the novel features which this ship possesses. In order to make the accounts clear and to illustrate some further description which we shall now add, we give on page 4729 engravings of some sketches taken from the ship. These engravings are as follow: Fig. 1 is a sectional elevation showing the positions of decks and the distribution of the various machinery compartments, magazines, store-rooms, etc.; Figs. 2 and 3 are the corresponding plans of the main and lower decks; Fig. 4 is a midship section of the ship; Figs. 5 and 6 are sketches showing how the Whitworth armor is put together and worked; and Figs. 7 and 8 show how the ram is constructed, and how the ram-head is carried and secured.

We may again enumerate the principal dimensions of the vessel: Length, 240 feet; extreme breadth, 40 feet; draught of water, 19 feet 6 inches forward and 20 feet 6 inches aft; and displacement, 2,640 tons. The upper deck, or turtle-back deck, as it is called, is 4 feet above the water line along its middle; but the form of the vessel is such that it curves down and enters the water at an angle of about 45°, so that according to the usual acceptation of the term the ship has no free-board whatever. A light superstructure forecastle is raised to a height of 4 feet 6 inches above the turtle-back to keep the bow up when the vessel is steaming at full speed, and upon this anchors and other fittings are placed. There is also a low superstructure aft to form a platform to walk upon and to give finish to the vessel. Between these two superstructures a wash strake is fitted so as to give a good sight line and to carry hand rails.

The water will sweep across the upper deck even in moderate weather; no attempt is made to keep it from doing so, but, as in all the low-sided war vessels in the British Navy, the principal hatchways are trunked up to a flying deck, from which alone the interior of the vessel will be accessible at sea. The flying deck is 10 feet 6 inches above the upper deck, and therefore 14 feet 6 inches above the water, and it extends between the forecastle and the platform deck aft. There is only a handrail around the flying deck, but three of the four hatchways which are trunked up open into circular




FORTY-THREE TON BREECH-LOADING ARMSTRONG GUN, IN CASEMATE.

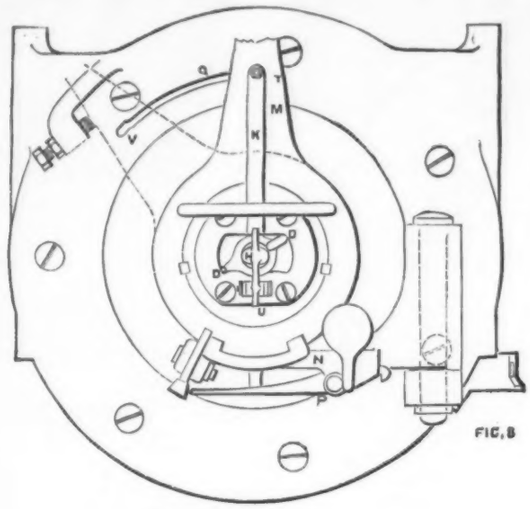


FIG. 8

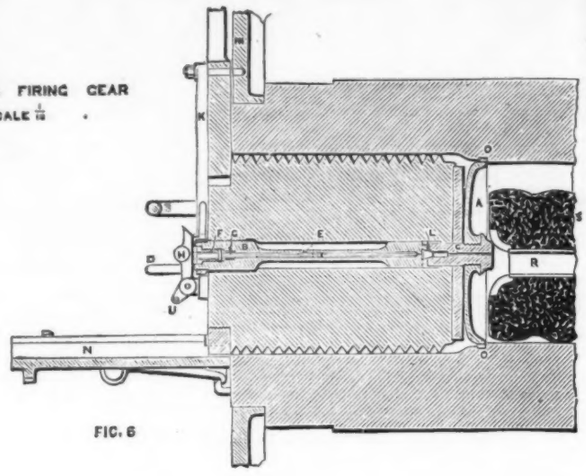



FIG. 6

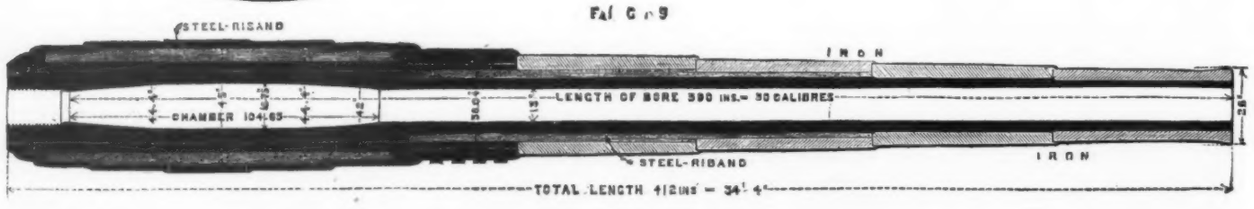



FIG. 9

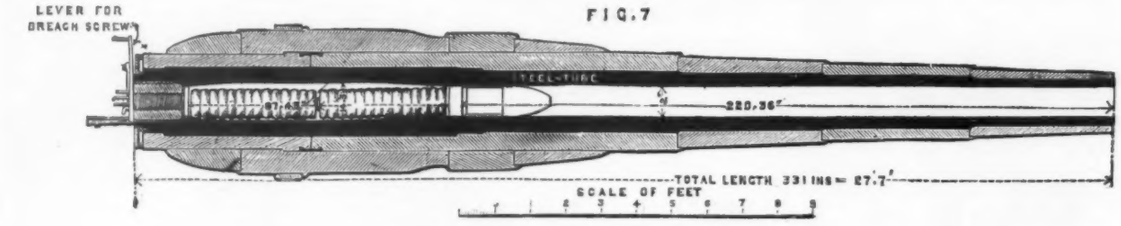



FIG. 7

## IMPROVED BREECH-LOADING GUNS.

deck-houses fitted with covers or hoods six feet or seven feet above the deck; the fourth trunk contains the funnel with its casing and air spaces, which also extend several feet above the deck, and may be closed in when required. The foremost trunked hatchway is divided into three by partition bulkheads, one, by far the largest of the three ways, leading to the forward part of the ship, including the torpedo-rooms and magazines, and the two smaller ones leading to each of the two forward stokeholds. The deck-house over this trunk will form the forward pilot tower, and will contain the steering wheel and the various implements for working and fighting the ship. The middle deck-house stands over a trunked way, which is also divided into three by partition bulkheads: two of these lead down to the aftermost stokeholds, and the third to the foremost engine-room. The aftermost trunk is divided into two, one passage leading down to the after part of the ship, and the other to the after engine-room. The deck house over this trunk forms the after pilot tower, and will be similarly fitted to the forward pilot tower. The central deck house may also be used as a pilot tower, but it will have no armor. The six Nordenfelt guns will be mounted in separate revolving turrets carried upon projecting framework at the level of the flying deck. There will be three of these on each side, one at the fore end of the flying deck, one at the middle, and the third at the after end.

The ship will carry four boats, two by davits from the flying deck ready for use, as on Fig. 1, and two others kept lashed up under the flying deck aft. She will also be fitted with two life rafts and gear for launching them in any weather. The position of these rafts is shown on Figs. 1 and 4.

Over the side of the turtle-back deck, to a depth of from four feet to six feet, there are three inches of steel armor, made up as follows: Two half inch thicknesses of Landore-Siemens steel, one of which may be regarded as the skin of the ship; upon these is a one inch thickness of Whitworth fluid-compressed steel, which will stand a strain of 45 tons per inch, and upon this again there is a one inch thickness of hard Whitworth steel, also fluid-compressed, worked in plates 10 inches square, which are tested to a strain of 68 tons. The two outer thicknesses of the side plating were supplied by Sir Joseph Whitworth in compound plates already bolted together and worked to shape, and only requiring to be fastened on the ship. The plates forming the under inch thickness are all 10 feet long and 2 feet 6 inches wide, so that each required thirty-six 10 inch squares, or scales, as they are called, to cover it. The scales are secured with coned steel screw bolts, placed as shown in Figs. 5 and 6, viz., one at the center of each of the plates, and one at each of the corners, so as to hold each of the four adjacent plates. Along the middle of the turtle-back deck the 10-inch scales are not fitted, so that here the armor is only 2 inches thick. The bases of the trunks from the hatchways to the flying deck are protected by a glacis of 6 inch steel-faced armor to a height of 3 feet 6 inches above the deck; and the entire front of the foremost trunk is protected by 8 inch steel-faced armor, which also extends to a height of about 5 feet above the flying deck, and gives protection to the pilot tower.

Those who are at all accustomed to considering the requirements of a vessel of this character will not be surprised to observe from the diagrams how completely filled the ship is with necessary fittings and stores, and how very little space is left for providing even requisite accommodation, to say nothing of ordinary comforts, for the officers and men. Excepting the low superstructure forecastle, there is no space above water available either for the stowage of stores or for accommodation, and this in a ship of 2,640 tons, and with engines of 5,500 indicated horse power, and having an available depth of hold of about 15 feet; whereas, in an ordinary ship of this displacement and power, space for nearly the whole of the accommodation and much of the storage would be found above the boundary at which the hull of the Polyphemus ceases. In groping our way over the ship, along the narrow passages under the low flats and into the various compartments, we found no corner that was not appropriated. The 103 men who form the crew may manage to live in the limited spaces allotted them forward on the main deck, but they will be barely comfortable, notwithstanding the elaborate ventilators both for conveying in fresh air and for removing foul air which pass along overhead and considerably limit the area over which it is possible to stand upright. The officers also will fare but little better in their quarters on the main deck aft; their accommodation is not luxurious. The round turtle-back form of the upper deck indicated on the midship section is preserved forward and aft, indeed it is sharper toward the extremities, so that out toward the sides of the living deck both forward and aft it will be impossible to stand upright.

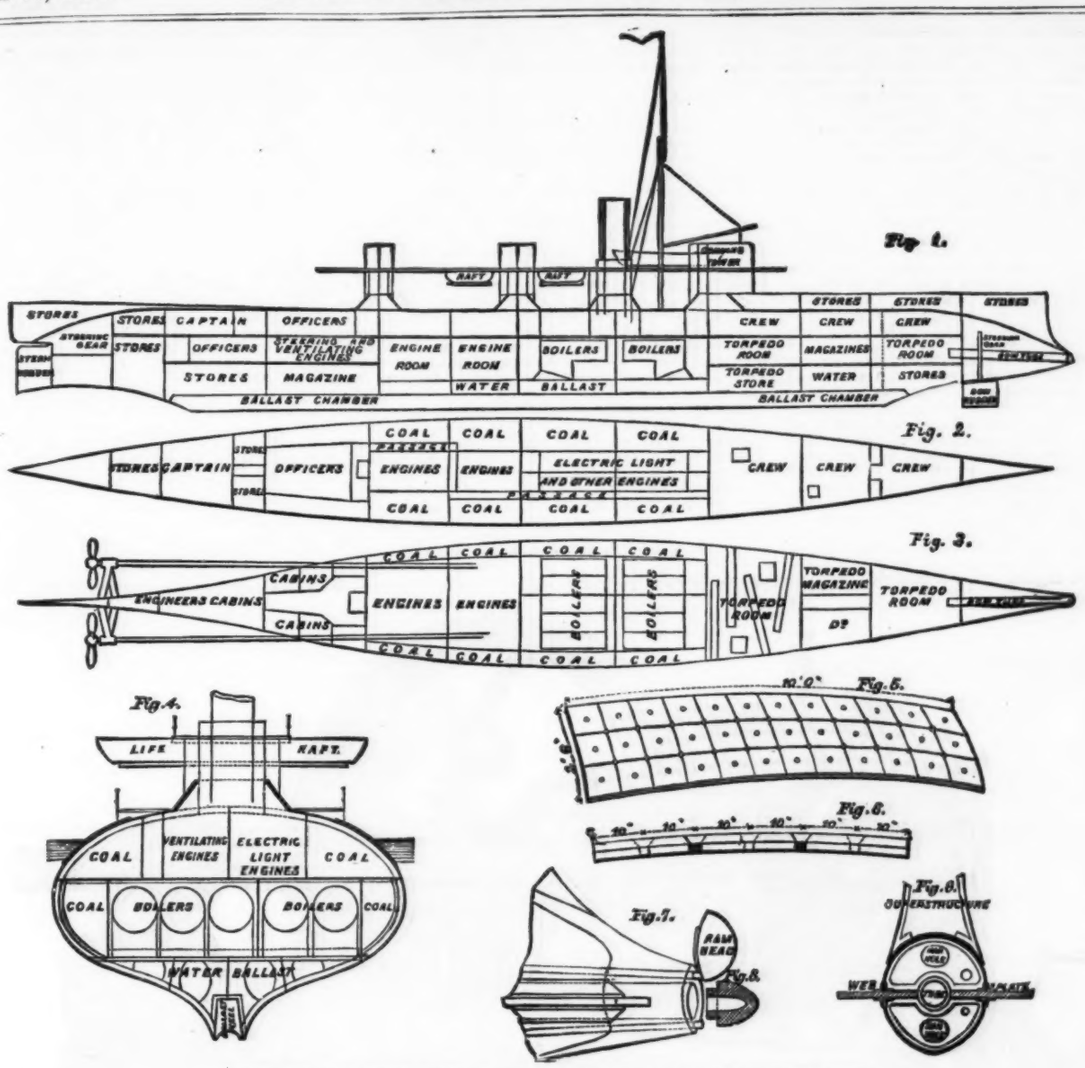
The whole of the central portion of the vessel over about one-third of the length is taken up by engines, boilers, and coal. As will be seen on reference to Figs. 1 and 3, the boilers are placed low down in the ship below the main deck; they are arranged in four water-tight compartments, three in each of those on the starboard side and two in each of those on the port. Over them on the main deck are placed the ventilating fans, electric light engines, and various other small engines. There are two separate engine-rooms, one before the other, the forward set of engines working the port screw and the after set the starboard screw. The coal (250 tons) is carried in sixteen bunkers placed as on Figs. 2, 3, and 4. The only communication below the upper deck between the compartments before the boilers and those abaft the engines is along a passage on the main deck, shown in Figs. 2 and 4, which is walled in with plating on either side and top and bottom, so as to form a water-tight tunnel. The various boiler and engine room compartments are accessible through water tight doors leading from this passage, as well as from above as already described. The vessel has two collision bulkheads to keep back the water in case her strongly framed bow should be strained in ramming. The chase torpedo tube extends from the ram to 2 feet or 3 feet abaft the inner of these collision bulkheads, and opens on the lower deck. Here the loading of this tube will be effected. Proceeding aft on the lower deck, the next compartment is allotted to torpedo magazines. Abaft this again is the main torpedo chamber, where there are four tubes, two on each side. Independent air-compressing machinery will be carried in each of the torpedo chambers, each of which chambers will also carry a number of torpedoes ready for use; the main store of torpedoes will, however, be carried in the hold under the floor of the main torpedo chamber. The main magazines for the Snider and Nordenfelt ammunition are in the after hold, but it is also intended to fit a small magazine for Nordenfelt ammunition forward. Besides the keel ballast, which may be cast loose at pleasure, a considerable weight of water ballast will usually be carried in the inner bottom compartments under the boiler and engine rooms.

Whether the Polyphemus will be able to crush in the side of her enemy with her long-pointed ram without her bow tube being so injured as to make it unfit for use, is doubted by most persons competent to give an opinion on the subject. The bow, however, is very strong, and great care has been taken to give the tube every chance of escaping uninjured. The tube proper is placed within an outer tube of great strength, against which, however, it does not rest except at its extremities, the outer tube being rigidly attached to and forming part of the framing of the bow. By continuing the armor down and attaching it to deep web plates which extend into the outer tube and out to 18 inches beyond the skin of the ship, an arrangement of great strength has doubtless been made. The front of the tube is a massive forging, which is continued aft, above and below the tube, and is well able to take care of itself. The ram-head also is of fluid-compressed steel, and is almost solid: when in place it extends into the tube several inches, so that against all blows from the front it is firmly held by the forging just referred to. The ram-head is worked from inside the ship by a steel rod to which it is fixed, and when in place it is also held by a rod below. In the position shown by Fig. 8 the ram-head is turned up clear of the tube.

Two auxiliary balanced rudders are fitted forward, one on each side of the bow torpedo tube. They are carried upon strong vertical shafts by which they are worked, and when not required are drawn up into trunks within the hull. When in use these rudders may if desired be coupled up with the engine working the stern rudder, and all three rudders worked together.

It is confidently anticipated that a speed of 17 knots will be attained at the measured mile, but it can scarcely be hoped that the vessel will be able to sustain this speed for many successive hours. The distance she will be able to cover at her six hours' trial of continuous steaming will really be the measure of her capabilities in this direction. A consideration of vital importance in this vessel is her maneuvering power. Her only modes of attack being the torpedo and the ram, she must necessarily constantly endeavor to come to close quarters with the enemy, or to keep out of range of his guns. With a speed of 17 knots she will be able to elect whether she will fight or not with almost any ship at present afloat, and supposing she chooses to fight, the chance of her success will depend almost entirely on the rapidity with which she will be able to close in with the enemy, and, having closed in with him, to maneuver around him, so as to bring her torpedo tubes successively into the line of fire and within range, and also to use her ram. The vessel will doubtless possess the power of turning rapidly: the powerful rudders at both ends of the ship, and the cutting away of the fore foot and the after "dead-wood" or heel, will insure this, but the question of the degree of handiness can only be settled satisfactorily by actual trials.

It could be wished that her armor was thicker, but when it is remembered that the only important parts are very oblique surfaces close to the water line, and that the vital parts, the boilers and magazines, are well protected by being many feet below the water line, this can scarcely be considered




## THE NEW BRITISH TORPEDO RAM POLYPHEMUS.

altogether unsatisfactory; moreover, her many water-tight subdivisions and detachable ballast make it probable that she might be hit at many points along the water line without being placed *hors de combat*. The Polyphemus is without doubt in conception a very formidable vessel, but she is novel and untried in many respects; in fact, there is scarcely anything about her which is not novel, and we look forward with much interest to her trial cruises.—*Engineering.*

Additional engravings and particulars of this remarkable vessel will be found in our SUPPLEMENT, No. 291, July 30, 1881.

### A HAND-MOVED PROPELLER.

AN Auburn inventor has patented a device for propelling boats which promises to entirely revolutionize the present laborious method of rowing. The inventor is Mr. Henry N. Staats, of this city, and the design of his appliance is to render practicable the use of a screw propeller upon small boats. The invention can be applied to any row-boat, and consists simply of a propeller shaft which projects through the stern of the boat, and has secured to its end a screw propeller which, by the rotation of the shaft by hand power applied to a double crank, causes the boat to move forward with greater or less speed, governed by the rapidity of the revolutions.

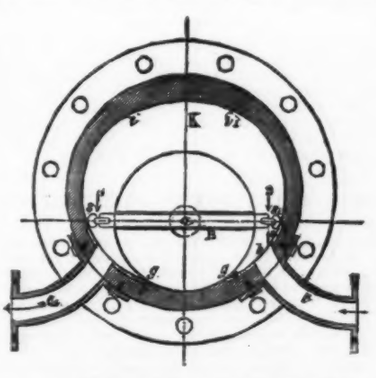
The work is not nearly so tiresome as rowing, and with the same amount of power expended, the speed attained is far greater. The advantages of the propeller are numerous and must be conceded. One is that the person faces the direction he is going, and can steer the craft himself by means of stirrups attached to a gear, also invented by Mr. Staats. In duck hunting you can noiselessly approach the feeding-ground and see where you are going. In trolling, this method of progression is also far superior to laborious rowing. Two or even more persons can work at the handles, which, by a simple change of a pin, can be worked in either direction, which is often a great relief to the muscles.

### A NOVEL HOLLOW YACHT MAST.

A MAST of novel style and construction has just been finished at the yard of D. J. Lawlor, naval architect, East Boston. It is intended for use in the sloop yacht Undine, which belongs to Benjamin Dean, Esq. The aim has been to produce a mast which should be at the same time light and strong, and, so far as the reduction of weight is concerned, a saving of about one-third has been effected. The spar is theoretically of adequate strength, but the actual test in a stress of weather has not yet been made upon it. It is a hollow mast, and so far is not a novelty, but the method of its construction differs from that of any hollow mast heretofore made. The usual plan has been merely to bore out the heart of the stick, which, of course, effects a saving of weight, but, as it had proved, carries with it a dangerous loss of strength. This spar has been constructed by first splitting the stick in halves. Then the heart of the stick has been dug or gouged out, so that the interior shape is somewhat like the hollow of a sugar-cane or bamboo. It is claimed that this, being nature's plan of producing a light yet inflexible stick, is the true method. The two halves being thus hollowed, the rough surfaces made by the saw in splitting were planed, and the two were glued together. At points where the offsets corresponding to the interior joints of the sugar-cane were made, dowels were inserted when the parts were glued together. On the inside, at that part of the mast where the gaff has its bearing, the shell was left somewhat thicker than above or below. The dimensions of the spar are: Length, 62 feet; diameter at the partners, 14½ inches; diameter at the hounds, 12 inches; thickness of the shell at the heel of the mast, 4 inches; midway, 2¾ inches; at the head of the mast, 1½ inches. For uniting the parts 124 three-quarter-inch dowels were used. These do not penetrate the stick so as to show from the outside, and when finished it is to all appearance an ordinary smooth white pine mast.—*Boston Advertiser.*

### HUTTER'S WATER-METER MOTOR.

THE water meter represented herewith is the invention of Mr. H. Hutter, of Gratz, and is designed to serve also as a



HUTTER'S WATER METER MOTOR.

motor by suppressing the registering mechanism. Its principal feature lies in the form of the section of the cylinder. In the interior of the latter there is an eccentric drum, in which moves a slide-valve, B, made tight against the side of the cylinder by elastic linings, surrounded by metallic coverings. The interior surface of the cylinder consists: of two circular parts, $g\,g_1$ and $s\,s_1$, whose common center corresponds with the axle of the drum; of two other circular parts, $s\,g$ and $s_1\,g_1$, concentric with the external surface of the cylinder; and of two bent parts, $i\,s$ and $i_1\,s_1$, whose form is given by the trajectory described by one of the extremities of the slide-valve when the other extremity slides over one or the other of the two circular parts, $s\,g$ and $s_1\,g_1$, the axis of the slide valve passing always during this movement through the center, $a$, of the drum. The liquid, entering through the tube, $e$, fills the spaces, K and $b$, through the grooves, $o$ and $o_1$, which are formed in the side in front of the aperture, $e$. When the outlet valve is open the water uniformly acts, in the manner shown by the arrows, 1, 2, and 3, on the projecting ends of the slide valve. The pressures 1 and 2 mutually annul each other, and pressure 3 communicates to the slide-valve a rotary motion, which is transmitted to the registering mechanism.

### LOCOMOTIVE IMPROVEMENT.

ALL recent improvements in the construction of locomotive engines have had for their object the diminution of wear and tear, rather than a reduction in the consumption of fuel per train mile. It admits of being proved that the more durable an engine is, the less coal will it consume; and so, of course, the better a locomotive engine is in material, workmanship, and design, the less fuel will it use; but this kind of economy is obtained incidentally, not purposely. It is clear that a reduction in coal bills can only be obtained by generating steam economically and using it to advantage. It is many years, however, since in this country anything has been heard about special cut-off gear; and the changes which have been made in the proportions of locomotive boilers are very few. Tubes 1½ in. in diameter are the smallest, and 2 in. in diameter are the largest used. The widest spacing is 1 in.; the closest, 5/8 in.; but both dimensions are abnormal, the one being a little less and the other a little greater than those usually adopted. In like manner the length of the tubes almost always lies between 10 ft. and 11 ft., and the heating surface is almost invariably arranged in the proportion of 60 of heating surface to 1 of grate surface, or thereabouts. It would appear that no better results than those now obtained can be had, no matter what changes are made in proportion; nor does it, indeed, seem to be possible to effect any improvement either in the use of steam or in its production. There is good reason to believe that the consumption of fuel in locomotives does not exceed 3 lb. per horse-power per hour, and in many instances where engines make long runs with loads which just suit them, the consumption of fuel is no doubt much less than this. Indeed, Mr. Stirling states that he has got down to a little over 2 lb. per horse per hour with some of his engines. The only attempts which are made to get away from existing rules of locomotive design take the direction of increasing the size of the cylinders to permit more expansive working. But these attempts have for the most part been failures; 1,100 square feet for 17 in. cylinders, 24 in. stroke, give admirable results independently of the diameter of the driving wheels, a result which is due most likely to the circumstance that the average number of revolutions made in one minute by a goods engine will be not far short of those made by a passenger engine, if we exclude

the highest speed at which passenger trains are run. Mr. Stirling, who attempted to depart from this rule, and used 18 in. by 28 in. cylinders with 8 ft. wheels, and a heating surface of 1,165 square feet, with 11 ft. 8 in. tubes $1\frac{5}{8}$ in. diameter and 217 in number, has had to enlarge his boilers by augmenting the size of his fire boxes—the only place where augmentation was possible—and with most satisfactory results. There is then, it would seem, reason to think that finality in the matter of relative proportions has been reached in this country, and that nothing can be saved by modifying them. The more carefully this truth is examined the more startling will it appear. The conditions of speed and load under which locomotives work vary very considerably, and a wide diversity exists between the qualities of the various coals used. Thus on the southern lines Welsh coal is burned, and in the north North-country coal. It might be thought that the boiler and furnace which would suit one would not suit another; but this is not the case, and whether dry Welsh coal or bituminous Northern coal is employed, the result is much the same.

Under such conditions the word improvement can only have one meaning when applied to locomotive engineering. Changes in design and proportions can only do good in the sense of keeping the locomotive out of the repair shop. There is room for improvement in this respect. It is well known that an enormous mileage can be got out of individual engines. Thus over 100,000 miles have been made with the most insignificant repairs; but the average for all the engines on a line may not be more than one-fifth of this. If the average performance of all locomotives could be raised to 50,000 miles per annum, without any repairs of importance, it would be a great thing for the railway companies. More than one locomotive superintendent has recently expressed his determination to get 100,000 miles out of each of his engines before it need visit the repair shops. Whether this result can or cannot be attained is an open question; but it is, at all events, well worth while to try to attain it. It can only be reached by paying the most scrupulous attention to a great number of details. For nothing, however, has an engine to be laid by so often as because of trouble with axle-boxes. When we consider how small is the bearing surface, and how heavy the loads, the wonder is that axle-brasses last as long as they do. An effective area of 40 square inches, or less, has to carry as much as seven or eight tons, representing a load of 450 lb. per square inch; and this is not only endured, but carried, without heating or cutting, day after day, for months together. But the very verge of endurance is no doubt reached; and it is well understood that an augmentation in the size of crank-shaft bearings, at all events, is highly desirable. This can only be got, properly, by increasing the length of the journals; and this, with inside cylinder engines and the ordinary type of valve gear, cannot be done. In the attempt to do it, outside crank cheeks have been made as thin as possible—thinner than, perhaps, it has been quite prudent to make them. Inside and outside bearings have been employed for the same purpose; but there is still room for change in this direction. Joy's valve gear, adopted by Mr. Webb, of Crewe, seems to have solved the problem. Last year the members of the Institution of Mechanical Engineers inspected at Barrow a goods engine fitted with this gear. The results of the work which has been done in the twelve months by this engine are, we understand, eminently satisfactory. With Joy's gear the valve chests are placed on top of the cylinders, and yet are driven direct without a rocking shaft. The cylinders can be got quite close together, and inside bearings alone of any required length can of course be employed. In this way the difficulty hitherto encountered in dealing with what are perhaps the most troublesome bearings in a locomotive are all got over, and it may be added that it also becomes possible to augment the lengths of the crank pins—an advantage worth having.

The method most in favor just now of keeping locomotives out of the repair shops consists in increasing their weight. Everything is heavier than it used to be. Engines of a given cylinder capacity weigh 10, 15, and even 20 per cent. more than their predecessors of the same cylinder capacity and heating surface did. It is not easy to see where progress in this direction—if it be progress—will stop. The rapidly extending use of the four-wheeled bogie has a good deal to do with the increase in the weight of locomotives. The modern English bogie is a tremendously heavy affair, and the extension of the engine frames in front over it, represents in itself a good deal of weight. It is to be hoped that the result obtained is worth the money. On this point there is, however, a great difference of opinion. Some English engineers like the bogie; others do not. One reason for its adoption is, however, that it saves the wear and tear of leading wheel tires, and an engine fitted with a bogie can keep at work, other things being equal, for this reason, longer than a six-wheeled engine. We have heard this disputed, and it has been argued that the small leading wheel of a bogie must wear out faster, as far as flanges are concerned, than the flanges of a 4 ft. leading wheel. The balance of argument is, we think, in favor of the bogie. Another point in its favor is that it really seems to do what American engineers claim for it—settle down the road in advance of the heavily-loaded drivers. Although weight is objectionable, in the sense that its adoption to make parts of a machine strong seems to be a crude and even rude expedient, yet it may perhaps be shown that the modern locomotive does not weigh an ounce more than it ought. It is not contended by any one that locomotives gain anything save durability from weight, and it is not too much to say that no one can say what the effect on repairs will be of an extra ton or two of metal in a locomotive. It is, however, quite certain that there is no uniformity of opinion among locomotive superintendents on the subject, many men of much skill and experience denouncing weight and keeping their engines as light as possible. It is to be regretted that it seems to be out of the question to get any figures which will show which policy is right.—*The Engineer.*

## CAST IRON COMPRESSION GIRDERS.

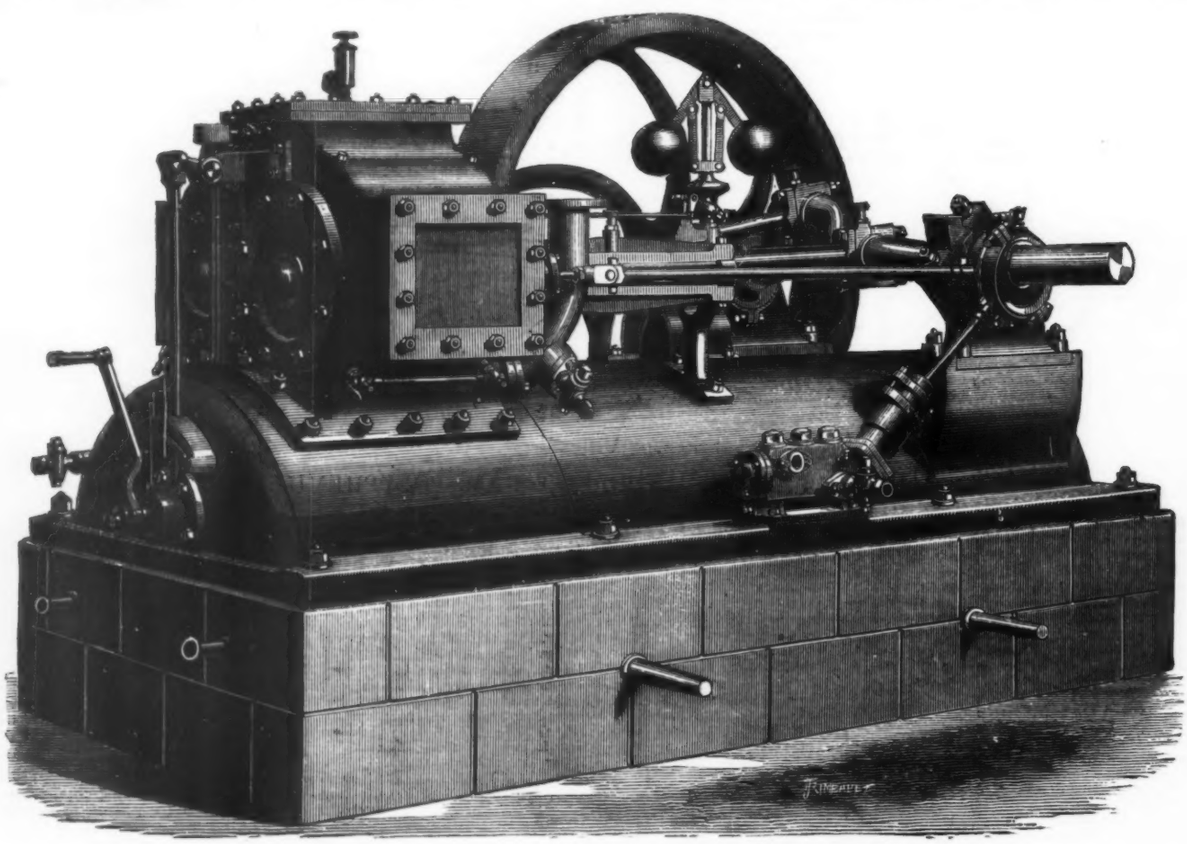
SOME interesting experiments were conducted recently at the Pacific Rolling Mills, San Francisco, with a new form of cast-iron girders, the invention of P. H. Jackson, late Chief of the Bureau of Iron Construction, Department of Buildings, in New York. The experiment, says the *Mining and Scientific Press*, was really one on a mode of using cast iron when subject to transverse strain, by which its whole cross section is compressively employed without taxing its comparatively feeble resistance. Before describing the girder, it may be well to bring forward for consideration some points on girders generally.

Cast iron possesses the enormous compressive resistance of 93,000 lb. to the square inch, while its tensile strength is but from 14,000 to 15,000 lb. The ratio computed by Mr. Hodgkinson is about $6\frac{1}{2}$ to 1.

The object attained in this construction is a perfect girder. When employed the bottom or tie rod is in tension, and the arch is in compression in every part with no tensile strain whatever; the latter an object not before attained. The antagonistic force of compression to resist the tensile strain of the tie rod is exerted at the bottom or intrados of the arch, and this force is increased in the ratio of the increment of the load on the arch. The remaining part of the arch above the bottom is naturally compression due to the load. A summary of the peculiarity of this arch is as follows:

It is in effect a device for employing cast iron compressively, neutralizing the tensile strain due to transverse strain. The tensile strain on the tie rods is reciprocally utilized in compressive resistance at the intrados of the arch, thus destroying tensile strain in every part of its cross section. Another advantage in construction of a metallic girder made in sections of its length is, that should the tensile strain at the intrados of the arch exceed that of compression by the action of the tie rods, the deflection of the arch is limited to the length of a bay only. For instance, in a girder 150 ft. in length, made in 10 bays, each 15 ft. long, the deflection that would injure the strength of the material of the arch is limited to the length of a bay of 15 ft., instead, as in other constructions, its weakness, by deflection, would extend over its whole length.

The neutral axis of this girder exists between the tie rod and the bottom or intrados of the arch, or midway between the antagonistic forces. With the segmental arch in one piece and the tie rod to resist, the neutral axis is near the bottom of the arch, and travels upward as the load is increased; as the neutral axis will exist wherever the two opposite forces cease to exist, being indifferent to either force. The economy in the use of this neglected material, cast iron, for long spans when subject to cross strain, is in the employment by which its tensile strength is not called into play; also another grave objection is by an unequal distribution of the metal, causing weakness in the casting when forming from the molten to the solid state, and from that condition until cold. The heavy parts in contraction control the thin or weaker parts, or, if the formation of the mould is such that the ends of a long casting set deep in it and offer a resistance to the contraction of the metal when forming from a liquid to a solid state, both of these adherent weaknesses continue and increase until cold. These weaknesses are entirely due to separation or taxing its comparatively feeble tensile strength, and not in the least injuring it in its compressive resistance, as cast iron is never in a contracted state other than cold; and as long as cast iron is used compressively, it makes no difference how many pieces it may be in of its length, providing its abutting parts squarely or equally meet and are kept in line. Take, for instance, the area of the abutting parts of the 25-ft. girder shown in the engraving, or the cross section of the



IMPROVED SIXTEEN HORSE COMPOUND ENGINE.

## SIXTEEN HORSE POWER COMPOUND FIXED ENGINE.

THIS engine is of a novel type which Messrs. Garrett and Sons, of Leiston, have designed to enable their portable engine details to be readily used for stationary purposes. Thus, in place of a frame of any ordinary pattern, they employ a cast-iron bedplate of semi-cylindrical cross section, this bedplate, in fact, representing the upper half of a portable engine boiler. On this bedplate are mounted the cylinders, crankshaft brackets, etc., of a portable engine of corresponding size, and a stationary engine is thus very readily built up. The particular engine shown is of the compound intermediate receiver type, with cranks at right angles, and the cylinders are respectively 9 in. and 18 in. in diameter with 12-inch stroke. The engine is intended to be run at 150 revolutions per minute, giving a piston speed of 300 ft. per minute.—*Engineering.*

STATISTICS have lately been compiled showing that, from 1858 to 1877, the wages paid French workmen have increased on the average 52 per cent. Although wine, meat, butter, eggs, and cheese have also increased in price, bread is not dearer and clothing is cheaper. House rent in the large cities is higher, however.

bottom flange in the center of a bay, which is 16 inches wide by 1⅛ inches thick, which equals 18 inches.

Eighteen inches multiplied by 93,000 lb. to the inch equals 1,674,000 lb., or 744 tons; taking it at one-fourth when employed, we have the resistance of 186 tons as a safe employed load. The area of the tie rods to resist this compression at 8 tons working strain per inch, providing the arch has suitable rise, would be 23¼ inches, or more than 3 of 3 inches in diameter rods. Tie rods are cheap—merely bars of wrought iron with threads and nuts. When a railroad train enters on a bridge borne by these girders, the opposite end to the train is prevented from rising by the abutting parts on the bottom of the arch compressively exerted. There is no part of the arch in which tensile strength is employed.

The object of this device was to construct a perfect girder, the whole arch resisting compression, the tensile strain necessarily exerted by the ties, and using this essential resistance to render indifferent a most destructive force to cast iron, viz., the tensile strain due to cross strain, showing an economy in this mutual antagonism, an equilibrium and forces negatived.

The inventor has endeavored to make a continuous arch embodying the principle of the Voussoir arch. Mr. Jackson's is a sectional, continuous arch, employed compressively over its entire cross section.

A Voussoir arch is composed of many blocks to make up its length, and without the use of cement or mortar between the blocks. With the exception of friction of the blocks as they slide downward, taking a more compressed position as the load upon them is increased or the abutments yield, there is no tensile strain whatever upon them, and the calculation has only to be made as to the strength of the material in its compressive resistance. With a continuous segmental arch, made in one piece of its length, there is, at every point, a bending moment and a thrust force; therefore, a continuous arch brings into play both compression and extension as that of a straight girder, but with more of compression than extension. See page 9 of W. Airy's book on "Iron Arches."

With an iron arch in one piece of its length, the wrought iron tie rods elongate in the ratio of 1-1000 of its length to every 10 tons tensile strain per square inch of cross section, and this elongation is considered the measure of the elastic force of the metal.

At this strain the elongation would be for a 25-ft. girder same as shown in the drawings, 3-10 of an inch. 25 ft. equals 300-1000 inch, equals 3-10 of an inch. At this elongation of the rods, be the material of the arch either of cast or wrought iron, the arch loaded will have so far straightened as to cause great tensile strain at the bottom, giving free play to the tensile strain caused by the load.

By this formation of cast iron into girders for long spans, using it compressively in the manner of employing cast iron columns, having a resistance of 60 per cent. in excess of wrought iron (that is, comparing the tensile strength of wrought iron at 95 tons to the inch, and the compressive resistance of cast iron at 41 tons, or the compressive resistance of wrought iron at 18 tons to that of cast iron), 41 tons is equal to 227 per cent. It is so shaped that its defective strength for long spans may be made in as short sections as desired, and the tensile strain on the rods as increased is utilized to destroy the power of the load to rupture the arch. The prime cost of the 25-ft. girder was $150. The girders in common use in this city to sustain 100 tons and 25 ft. long, supported only at the ends, are sold at about $350 each.

Fig. A, of the engraving, is an elevation of a girder experimented on. Length, 25 ft.; distance between supports, 23 ft. 2 inches; height, from bottom of tie to under side of arch, 2 ft. 3 inches. The cross section of arch (see Fig. B) was 16 inches wide by 1¼ inches thick at bottom, and the greatest height 10 inches. Two of 2¼ inches diameter wrought iron tie rods sustained the tensile strain. Figure C shows the knuckle joint, the round cast on the center piece, and the socket cast on end pieces, and with the strut cast on same piece, this latter resting on the bottom on the tie rods. Fig. D shows end of girder. At the top of the arch will be seen a space of 1¼ inches. Whatever may be the deflection, no parts of the arch, excepting the knuckle joint, touch, so that compression is only exerted on the line of the bottom flange. The cross section of arch (see Fig. B) is of the Hodgkinson form for straight girder and made to sustain a 16-inch brick wall; consequently, from its broad bearing for the wall, it is largely in excess in compressive resistance to the tensile capacity of the rods. The following is the cost of this girder in San Francisco, where materials and labor are higher than in the Eastern cities and in Europe:

| | |
|---|---|
| Weight of arch casting, 3,080 lb., 3¼ c. | $100.10 |
| Weight of tie rods and nets, 902 lb., 4½ c. | 40.59 |
| Fitting 4 bolts and lead | 5.50 |
| Drayage and painting | 3.00 |
| | $149.19 |

Had this been made to sustain 186 tons as a safe load, the breaking load three times greater—the same casting to be used, but to have three of 3 inch diameter rods, it would have cost:

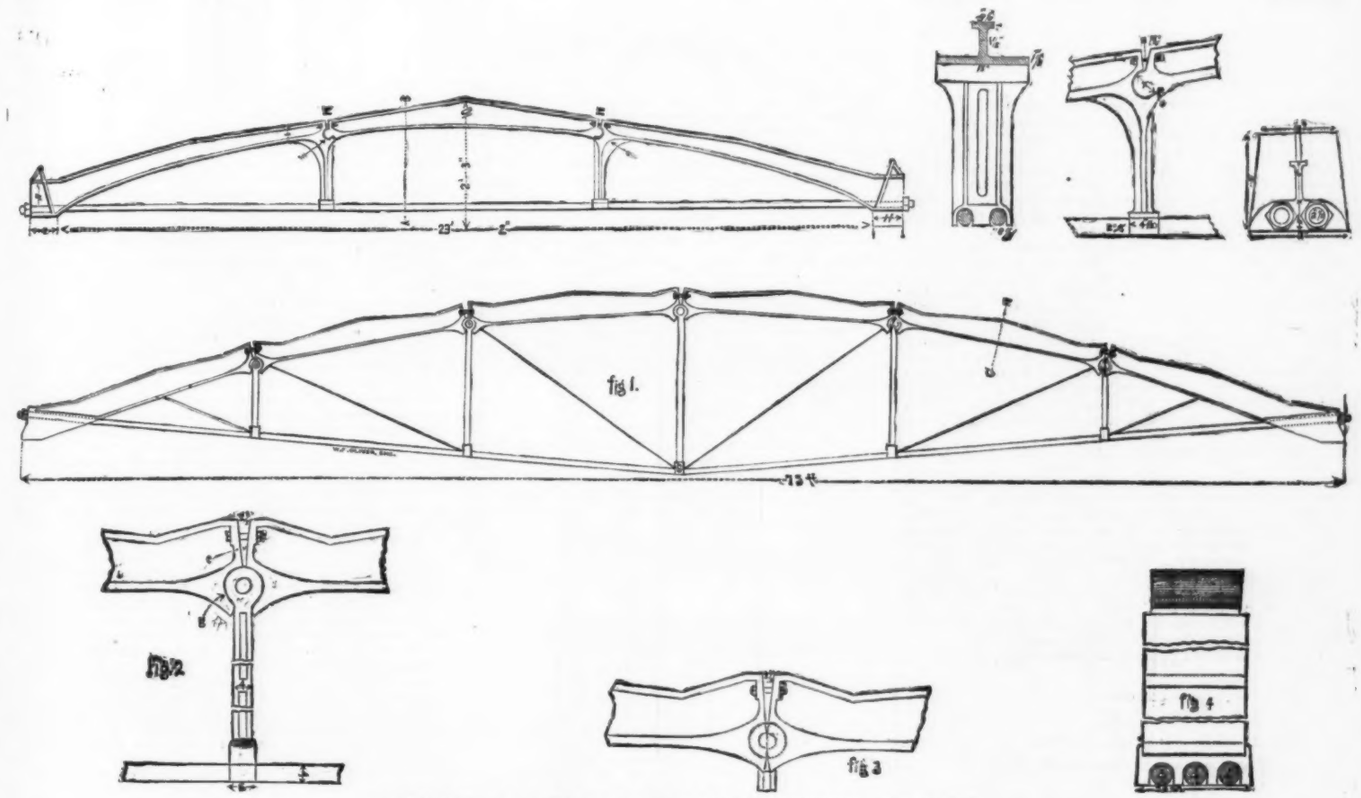
| | |
|---|---|
| 3,080 lb. casting, as before | $100.10 |
| 3 3 inch rods, 1,848 lb., 4¾ c. | 87.78 |
| Other expenses | 9.50 |
| | $197.38 |
| Difference | $48.19 |

In the experiment at the Pacific Rolling Mills, the other day, this girder was loaded with 117 tons and 1,741 lb. of railroad iron, the length between the supports. Under the weight it deflected at the joints a quarter of an inch below the true arc. The foundation on which the girder rested settled seven inches, so that loading had to be stopped. I have no doubt it would have carried 225 tons, or until the rods broke. At each of the abutting ends a lamina of lead was used to fill in between the castings, which were not nicely fitted, as the strength at this place was so much in excess of requirements. This was to make up for the irregular surfaces, the draught of the pattern making it fuller in the middle in each piece. To make up for the closing up part of the lead when the compressive force was exerted, as well as to straighten the tie rods when loaded, the arch was cambered three-quarters of an inch at the joints above the true arc. The same rule applies to each one of these three sections as that of a continuous arch in one piece of its length; that is, they are subject to a bending moment and a thrust force, and both compression and tension are brought into play, as that of a straight girder, but less of tension than compression, being of arch form, as mentioned in a previous part of this article. But it must be borne in mind that the compressive force exerted on each of these three short arches or sections of the long arch, equivalent to three small girders, each 7 ft. 9 inches long, is equal to the compressive force of the whole length, 23 ft. 3 inches.

While the compressive and tensile force transversely exerted is only due to the load on a length of 7 ft. 9 inches, therefore the compressive force to resist the tie exerted on a single section of 18 ft. 9 inches, consisting of 8 bays, making the entire length of girder 150 ft., is eight times that it would be if the girder was only 18 ft. 9 inches, so by a proper number of bays suitable to the length, this may be so regulated as may best suit any desired end.

Figs. 1, 2, 3, 4, and 5 are a railroad bridge which may be made 500 ft. in length, and of a suitable number of bays. It will be seen that the top of strut is round, and the ends of arch are socketed to meet the round of the strut. Provision is made to prevent the girder rising by being loaded only on one end with a tendency to rise at the other, as that of a railroad train on the one end. This is effected by the bottom edges of casting pressing together. It will be seen that the ends of arch on outside inclose the strut. Provision against lateral deflection is made for long spans by widening the ends where they abut and inclose the strut. To sustain the bridge floor wrought iron rods, or suspenders, may run inside or on outside of the cast-iron strut, or a wall on top and floor beams laid on it.

This construction, weighed in all its bearings, Mr. Jackson thinks will be found to be much cheaper for equal strength than any now in use. Girders of long spans for a bridge can be made as it were in a day, and taken to the place of destination and readily put together. By this mode of construction Mr. Jackson is convinced he has found a means to apply for the world's use the heretofore universally condemned cast iron, when used for long spans and subject to cross strain, as well as overcoming the inherent fault caused by the unequal distribution of the metal causing weakness if not positive rupture unobservable, made to exist by contraction of the metal in cooling.




## IMPROVED CAST IRON COMPRESSION GIRDER.

## LAYING OUT ANNULAR WHEELS.

*To the Editor of the Scientific American:*

I beg space to call attention to one matter which appears in connection with the admirable article of Professor C. W. MacCord, of the Stevens Institute, in SUPPLEMENT No. 291, detailing his discovery of limitations in the theory and construction of *annular wheels* in practice.

I think there is no intention to do an injustice to either of the odontographs mentioned in the article; though I think the casual reader might get an impression that neither instrument could be used to lay out the wheels correctly according to Professor MacCord's limits. A subsequent statement in SUPPLEMENT No. 294 clears up the question regarding Willis's odontograph, but does not touch all the facts pertaining to the Templet odontograph, doubtless for the reason that Professor MacCord's limits were not anticipated when the rules for use of that instrument were written.

But it should be understood, nevertheless, that the facts and rules stated in the printed instructions sent out with every Templet odontograph provide completely for all the practical limits discovered by Prof. MacCord. Though this is true, yet it would be better that the rule for annular or internal gears, for the Templet odontograph, be now rewritten with the above-named limits especially in view.

To briefly indicate that the Templet odontograph and accompanying rules are sufficient for the newly discovered limits, I would add the following:

The heading to the first column of the table reads:

"*Radius of wheel sought divided by the diameter of the generating circle, or Ratios.*

This *ratio* is, in the rules, denominated "*Tabular Ratio,*" and hence its significance is known. Therefore when we turn to the rule for "*Internal Gears,*" and read, "Divide radius of each wheel by any number not greater than radius of pinion for *Tabular Ratio,*" we are assured that this "number" stands for the diameter of the generating circle.

Hence, to proceed correctly in the use of the Templet odontograph to lay out annular wheels according to Professor MacCord's limitations: First find the particular generating or describing circle admissible, according to Professor MacCord's rules for limits; then measure its diameter, and also the radius of the pitch circle whose teeth are sought to be laid out, and divide the latter by the former. This is the proper *Tabular Ratio* with which the "setting numbers" are to be obtained from the table, and the teeth correctly laid out.

I admit that a person in laying out *annular wheels,* differing not greatly in size as in certain hoisting gear, would by means of the Templet odontograph, and accompanying rules, and without the light of Professor MacCord's discovery, be quite likely to have trouble with them when put into use; but at the same time, with a knowledge of the discovery, the existing rules are sufficient for correct laying out.

S. W. ROBINSON,
Mechanical Department, Ohio State University.

## ON THE EFFECT OF PROLONGED STRESS UPON THE STRENGTH AND ELASTICITY OF PINE TIMBER.

By PROF. R. H. THURSTON.*

IN papers read before the American Society of Civil Engineers at various dates† the writer has given the results of investigations made to determine the behavior of metals under loads of varying magnitude and under intermitted stresses, and to ascertain in what cases and under what conditions the variation with period of stress of the normal line of elastic limits, discovered and announced by him in the year 1873, occurs in practice. Experiments made by Mr. Herman Haupt,‡ forty years ago, revealed a fact not even now generally understood and appreciated—that timber may be injured by a prolonged stress, far within that which leaves the material uninjured when the test is made in the usual way and occupies a few minutes only.

Thus, using pieces 60×3×1 inch (152·4×7·62×2·54 cm.) set as cantilevers, with a breaking moment, due the load, of $Pl$=48 P inch-pounds (132 $P_m$ kilosmeters), he obtained for the value of $R=\frac{6\,w\,l}{b\,d^2}$ the following figures:

| Kind of Wood. | R. | Time. | Remarks. |
|---|---|---|---|
| White Pine..... | 2,372 | 10 min. | Injured. |
| " ..... | 1,548 | 16 days. | " |
| Hemlock... ..... | 2,624 | 5 min. | " |
| " ..... | 1,620 | 16 days. | " |
| Yellow Pine..... | 2,848 | 5 min. | " |
| " ..... | 1,800 | 16 days. | " |
| Locust..... | 5 504 | 2 min. | Not injured. |
| " ..... | 3,600 | 3½ days. | Injured. |
| " ..... | 3,304 | 16 days. | " |
| White Oak..... | 4,248 | 15 min. | Not injured. |
| " ..... | 7,200 | 15 min. | Injured. |
| " ..... | 3,648 | 40 hours. | Not injured. |
| " ..... | 4,088 | 48 hours. | Injured. |

All samples tested were considered good selected timber.

An extended series of experiments made intermittently in the Mechanical Laboratory of the Stevens Institute of Technology, Department of Engineering, during some years past, has included an examination of this subject, and the result has confirmed Haupt's earlier work, and has given a tolerably good idea of the effect of prolonged stress in modifying the primitive relation of stress and strain where the wood is good southern yellow pine.

A selected yellow pine plank was obtained for test, the history of which was known. The stick was cut at Jacksonville, Florida, in October, 1879, was received early in the following year, and was piled up in the yard, air-seasoning until taken for the test in the spring of 1880. The plank measured 4"×12"×24" (10·16×30·48×731·52 cm.). When tested it had been seasoning six months, the latter part of the time in-doors. From the middle of this plank a stick was first cut, 3"×3"×24" (7·62×7·62×731·5 cm.), and from this was cut a set of ten pieces from 40" to 54" long (101·6 to 137·2 cm.) and from 1¼" to 3" square in cross section (3·16 to 7·62 cm. square). The moduli of rupture were usually 11,000 to 12,000 for the expression $R=\frac{3}{2}\frac{P\,l}{b\,d^2}$ (in metric measures, 773·3 to 843·6), and the moduli of elasticity ranged from two to two and a quarter millions (in metric measures, $10^6\times1406$ to $158175\times10^6$). In specific gravity the wood ranged from 0·75 to 1·00, usually 0·85. When kiln-dried to a moderate extent the density was but little altered, if at all, but the modulus of elasticity rose to two and a half millions ($17375\times10^6$), and the modulus of rupture was increased about 20 per cent. From the previously unused part of the plank, a set of three test pieces was cut about one inch (2·54 cm.) square in section, and tested on supports 40 inches (101·6 cm.) apart to determine their breaking loads.

The result is shown in detail in the appended table No. 1.

TABLE I.

A. $b$=1·113; $d$=1·105. B. $b$=1·107; $d$=1·107. C. $d$=1·1; $b$=1·1.

Distance between supports=40 inches.

| Load Lb. | Deflections. In. | Load. Lb | Deflections. In. | Load. Lb. | Deflections. In. |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0·2127 | 50 | 0·2035 | 50 | 0·2188 |
| after 5 m. | 0·2164 | after 5 m. | 0·2125 | after 5 m. | 0·2231 |
| 100 | 0·4339 | 100 | 0·3935 | 100 | 0·4528 |
| after 5 m. | 0·4378 | after 5 m. | 0 4000 | after 5 m. | 0·4623 |
| 150 | 0·6575 | 150 | 0·5805 | 150 | 0·6833 |
| after 5 m. | 0·6696 | after 5 m. | 0·5885 | after 5 m. | 0·6950 |
| 200 | 0·8984 | 200 | 0·7640 | 200 | 0·9298 |
| after 5 m. | 0 9146 | after 5 m. | 0·7730 | after 5 m. | 0·9468 |
| 250 | 1·1552 | 250 | 0·9630 | 250 | 1·2038 |
| after 5 m. | 1·2246 | after 5 m. | 0·9775 | after 5 m. | 1·2433 |
| 300 | 1·5109 | 300 | 1·1805 | 300 | 1·5648 |
| after 5 m. | 1·5931 | after 5 m. | 1·2180 | after 5 m. | 1·6713 |
| after 6 m. | 1·6029 | 350 | 1·4705 | after 6 m. | 1·6883 |
| 350 | 1·9329 | after 5 m. | 1·5581 | 325 | 1·8568 |
| 380 | broke. | after 6 m. | 1·5700 | 340 | splinter'd |
| | | 410 | Broke. | 345 | Broke. |

In these specimens, the annual rings were, in the cross sections of each piece, indicated by lines making angles of 45° with the edges. These pieces broke at 345, 380, and 410 pounds respectively. The weakest piece broke by splintering, and had it been as sound as the others, would probably have sustained a somewhat heavier load. As will be seen by comparison with the other and with subsequent tests, the deflection of the strongest piece in the set is exceptionally small, and the piece probably exceptionally strong and stiff. We may, therefore, take 375 pounds (170 kilos), or a trifle over, as a good average for loads breaking pieces of this size.

Nine other pieces were cut and dressed to the same size, and were mounted on supports 40 inches apart, in a frame arranged for the purpose in the workshop of the Institute, in three sets of three each.

These sets were loaded thus:

1st set, 250 pounds (113·6 kilos). Table 2.
2d " 300 " (136·4 " ) " 3.
3d " 350 " (158·1 " ) " 4.

or to about 70, 80, and 95 per cent. of their probable maximum strength as indicated by ordinary test of the companion lot above described. Their deflections were measured when set, and at intervals subsequently, by means of an accurate micrometer reading to the ten-thousandth of an inch.

The whole set of bars loaded most heavily, as above, broke within two days, one bar yielding, as shown in Table 2, at the end of a period included between observations taken at 41¼ and 13½ hours from the beginning, the second breaking at some time between 27 and 30½ hours, and the third giving way at the end of 43 hours. A load of 87½ the maximum obtained by usual methods of tests is thus shown to be capable of breaking the piece under the conditions here described, and an apparent factor of safety of 1½ is evidently not a factor of safety at all when time is given for the piece to yield.

TABLE II.

A. $b$=1·1; $d$=1·1. B. $b$=1·12; $d$=1·12. C. $b$=1·1; $d$=1·1.

Distance between supports=40 inches.

| Load. Lb. | Time Load was applied Hours. | Deflection. In. | Time Load was applied Hours. | Deflection. In. | Time Load was applied Hours. | Deflection. In. |
|---|---|---|---|---|---|---|
| 40 (weight of box) | — | 0·1565 | — | 1·705 | — | 0·1840 |
| 350 | — | 1·7350 | — | 1·7175 | — | 2·0300 |
| | | | bet. | | | |
| | 18 | 2·3385 | 27 | | ¼ | 2·3500 |
| | | | and | Broke | bet. | |
| | 43 | Broke | 30½ | | 41½ | Broke |
| | | | | | and | |
| | | | | | 13½ | |

The second set, loaded with 0·75 the maximum momentary weight, all broke, as is shown by Table 3, one at the end of about three and a half days, another after five days, and the third at the end of a little over a month. It is probable that these differences of time are due to differences of strength more than to variations of the effect of time of stress. A factor of safety of 1½ is evidently not a real factor of safety for such cases as this.

TABLE III.

A. $b$=1·11, $d$=1·08. B. $b$=1·1; $d$=1·12. C. $b$=1·1; $d$=1·12.

Distance between supports=40 inches.

| Load. Lb. | Time Load was applied. | Deflection. Inches. | Time Load was applied. | Deflection. Inches. | Time Load was applied. | Deflection. Inches |
|---|---|---|---|---|---|---|
| 40 (weight of box) | — | 0·1641 | — | 0·1470 | — | 0·1930 |
| 300 | — | 1·4461 | — | 1·1215 | — | 1·6725 |
| | 1 | 1·5980 | ½ | 1·1835 | 1 | 1·8660 |
| | 3 | 1·666 | 3 | 1·2370 | 2 | 1·8950 |
| | 5 | 1·7·16 | 4¼ | 1·2735 | 18½ | 2·24 0 |
| | 22¼ | 1·9171 | 5 | 1·2770 | 44 | 2·5450 |
| | 47½ | 2·1020 | 21¾ | 1·4280 | 50 | 2·592) |
| | 54 | 2·1316 | 46¾ | 1·5485 | 66½ | 2·7310 |
| | 70½ | 2·2596 | 69¾ | 1·6380 | 74½ | 3·30..0 |
| | 78½ | 2·4706 | 77¾ | 1·7740 | bet. | |
| | 95½ | 2·7586 | 94¾ | 1·8505 | 79½ | Broke |
| | 118½ | 3·0586 | 117¾ | 1·9360 | 88½ | |
| | 121 | Broke | 141¾ | 1·9610 | | |
| | | | 165¾ | 1·9830 | | |
| | | | 189¾ | 2·0050 | | |
| | | | 238 | 2·0280 | | |
| | | | 262 | 2·0440 | | |
| | | | 286 | 2·0580 | | |
| | | | 310 | 2 0630 | | |
| | | | 335 | 2·0810 | | |
| | | | 359 | 2·110 | | |
| | | | 406 | 2·13·0 | | |
| | | | 430 | 2·2110 | | |
| | | | 454 | 2·2820 | | |
| | | | 478 | 2·4570 | | |
| | | | 502 | 2·5510 | | |
| | | | 526 | 2·5870 | | |
| | | | 598 | 2 6435 | | |
| | | | 622 | 2·6520 | | |
| | | | 646 | 2·6600 | | |
| | | | 919 | Broke | | |

TABLE IV.

P=250 lb.

A. $b$=1·08"; $d$=1·1". B. $b$=1·08"; $d$=1·1". C. $b$=1·1"; $d$=1·1".

Distance between supports=40 inches.

| Load. Lb. | Time Load was appli'd. Hours. | Deflection. In. | Time Load was appli'd. Hours. | Deflection. In. | Time Load was appli'd. Hours. | Deflection. In. |
|---|---|---|---|---|---|---|
| 37 (w't. of box.) | — | 0·1342 | — | 0·1532 | — | 0·1260 |
| 250 | — | 1·0317 | — | 1·0403 | — | 0 98 1 |
| | 91 | 1·2927 | 90 | 1·3757 | 89 | 1·2696 |
| | 161½ | 1·3967 | 160½ | 1·5132 | 159½ | 1·3796 |
| | 185½ | 1·4077 | 184½ | 1·5402 | 183½ | 1·4076 |
| | 210½ | 1·4237 | 209½ | 1·5592 | 208½ | 1·4246 |
| | 233½ | 1 4372 | 232½ | 1·5862 | 231½ | 1·4446 |
| | 258½ | 1·4942 | 257½ | 1·6602 | 256½ | 1·5196 |
| | 281½ | 1·5227 | 280½ | 1 7042 | 279½ | 1·5651 |
| | 305½ | 1·5337 | 304½ | 1·7217 | 303½ | 1·5736 |
| | 329½ | 1·5547 | 328½ | 1·74 2 | 327½ | 1·5866 |
| | 353½ | 1·5657 | 352½ | 1·7492 | 351½ | 1·6008 |
| | 402 | 1·5797 | 401 | 1·7662 | 400 | 1·6216 |
| | 426 | 1·5897 | 425 | 1·7762 | 423 | 1·6286 |
| | 450 | 1 5957 | 449 | 1·7 54 | 448 | 1 6346 |
| | 474 | 1·5997 | 473 | 1·7872 | 472 | 1·6396 |
| | 499 | 1·6907 | 498 | 1·8032 | 497 | 1·6506 |
| | 523 | 1·6257 | 522 | 1·8132 | 521 | 1·6656 |
| | 570 | 1·6617 | 569 | 1·8632 | 568 | 1 6916 |
| | 594 | 1·7047 | 593 | 1·8832 | 592 | 1·7326 |
| | 618 | 1 7417 | 617 | 1·9522 | 616 | 1·7646 |
| | 642 | 1·777 | 641 | 1·9982 | 640 | 1·8066 |
| | 666 | 1·8187 | 665 | 2·0342 | 664 | 1·8436 |
| | 690 | 1·8347 | 689 | 2·0522 | 688 | 1·8566 |
| | 762 | 1·8677 | 761 | 2·0852 | 760 | 1·8866 |
| | 786 | 1·8777 | 785 | 2·0932 | 784 | 1 8946 |
| | 810 | 1·8827 | 809 | 2·1032 | 8 8 | 1·9026 |
| | 1195 | 1·9832 | 1194 | 2·1822 | 1193 | 1·9906 |
| | 2107 | 2·1777 | 2206 | 2·3912 | 2105 | 2·1696 |
| | 2923 | 2 2757 | 2922 | 2·4917 | 2921 | 2·2676 |
| | 6715 | 2·9297 | 6066 ± | Broke | 6713 | 2·6416 |
| | 8899 ± | Broke | | | 11100 ± | Broke |

The increase of deflection was almost precisely the same for all for several months, a fact which is of importance, as showing not only the gradual progress and the steadiness of yielding, but also that no accident produced final rupture. Finally, after several months (about 6,000 hours, the exact time is uncertain), the piece which had at the beginning shown most pliability, broke down completely. The next piece to break was that which was intermediate in stiffness between the two others; it broke at the end of about 9,000 hours—precisely one year from the date on which the load was imposed. The last of the three pieces of this set still carried its load of 60 per cent. of the maximum under ordinary test, at the last date, but was still very slowly but unmistakably yielding its deflection having increased nearly 0·4 inch (1·01 6 cm.) during the preceding five months. *It finally broke July 31, 1881, about eleven thousand one hundred hours after it received its load* (15 months), which load was, it will be noted, but about 60 per cent. of its estimated, and probably practically correct, original breaking weight

This very remarkable result fittingly terminated this series of tests of strength of wood subjected to prolonged stress.

Comparing the ultimate deflections attained by the several sets of bars, it is seen that the average under ordinary test was about 1·8 inches (4·6 cm.). Under a load 0·95 that then carried, the rods broke at a deflection of 2·4 inches (6 cm.); loaded to 0·80, the maximum deflection became, at the end 3 inches (7·62 cm.) as a maximum, and the ultimate deflection of the most lightly loaded pieces (60 per cent. the maximum load) was something less.

The last set being compared with the first, it is seen that a load of 30 per cent. the maximum given by the usual form of test is for such pieces unsafe, and that one-half the ultimate deflection under usual methods of test marked a point beyond which loads become certainly unsafe, although it would seem that a slightly smaller load might have been carried indefinitely until decay should weaken the timber. A factor of safety of 2 would probably have permitted indefinite endurance under static load. Taking the probable breaking load, under unintermitted stress, as 60 per cent. that sustained as a maximum under usual tests, and then applying a factor of safety of 2, we obtain as a safe factor, based on the ordinary test, FOUR.

The writer would conclude, then, that timber may be placed with the "tin-class" among metals, as exhibiting a depression of the normal series of elastic limits under prolonged stress, and that this effect is so serious in its character, and so important in its effects, that an extended and complete investigation of the phenomena, as exhibited in timber of various sizes and of all the kinds in use in engineering or in construction generally, would be of great value, if not imperatively demanded. In brief:

The conclusion to be drawn from the research here described as having been made during the past fifteen months, in the Mechanical Laboratory of the Department of Engineering of the Stevens Institute of Technology, are, evidently, that small sections of yellow pine timber yield steadily over long periods of time, under loads exceeding 60 per cent. the maximum obtained by ordinary tests of their transverse strength, and finally break, after a period which, with the lighter loads, may exceed a year; that deflections half the maximum reached under test may be unsafe for long periods of time, and that a factor of safety of at least 4 should be used for permanent static load, when the character of the material is known.

The writer would, in the light of what is now known, always use a factor of safety of at least 5 under absolutely static load, and, when the uncertainties of ordinary practice as to the exact character of material, and especially where shake and the impact of live load were to be considered, would make the factor not less than 8, and for much of our ordinary work, 10.

The above experiments were arranged and supervised by Mr. J. E. Denton, and the observations made and recorded by Mr. A. Riesenberger, to both of whom the writer is under great obligations for intelligent and zealous assistance and co-operation in this as in many earlier investigations.

## NEW THERMO-SIPHON OR HEATER.

IN addition to domestic heating apparatus, such as stoves and grates, which are exceedingly barbarous, regarded from the standpoints of hygiene and economy, three rational systems of heating vie with each other for public favor—heating by circulation of steam, by circulation of hot air, and by circulation of hot water. In the first two of these systems the circulation of the heating medium being inclosed, and taking place under pressure, there are necessarily dangers of explosion Under the same circumstances there would exist the same dangers in the third system, but fortunately the circulation of a liquid can take place in open air.

Where the circulation is inclosed there is another grave inconvenience, and that is the impossibility of regulating the temperature. In the open-air circulation of water, however, the temperature is regulated spontaneously by the effect alone of evaporation, which prevents the liquid rising to a temperature above its vaporizing point. Heating by hot air and steam has still another inconvenience, and that

* Read before the American Association, Cincinnati, August, 1881.

† Trans. Am. Soc. C. E., 1873-80; *Jour. Franklin Inst.*, 1874, etc., etc.

‡ Haupt on Bridge Construction.

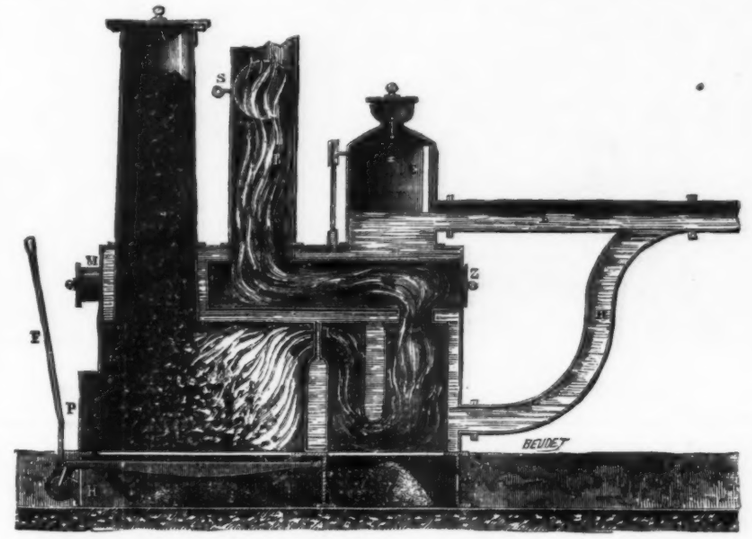
‖ Trans. Am. Assoc. Advancement of Science, 1879-1880; *Jour. Frank. Inst.*, Oct., 1879, Sept., 1880.

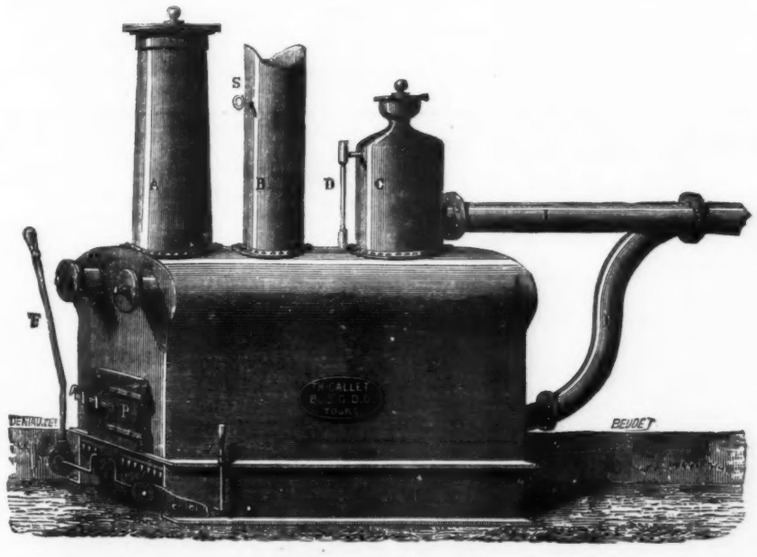
is the rapid radiation of heat and consequent depression of temperature, if the temperature of the fire-place itself happens to lower; while water, which is a bad conductor of heat, cools very slowly, and preserves for a long time a temperature which is sensibly equable, even when the fire which has heated it chances to go out. For all these reasons, thermo-siphons, which give without much attention that regular temperature so indispensable to plants, have long been used for heating hot-houses.

In recent years attention has been turned to the fact that these apparatus, so salutary to plants, might prove equally so as a source of heat for human habitations. Acting on this hint, Mr. Gallet, a manufacturer at Tours, who has long been engaged in the construction of thermo-siphons for heating green houses, has just undertaken the manufacture, on a large scale, of apparatus of this kind adapted for heating dwellings and especially schools.

These thermo-siphons are made on a new system, and, owing to the dimensions and the arrangement of the grate, one of them will remain charged for twenty-fours hours at a minimum, while the reservoir is calculated to furnish the water necessary for a still longer time.

The grate, which is automatic and reversible, needs scarcely any watching. The heating surface in the apparatus is very wide, thus allowing of a rapid heating of the water, and doing away with the only inconvenience attached




NEW THERMO-SIPHON OR HEATER.

to hot-house thermo siphons—that of the delay in getting them started. Finally, there is another improvement that the manufacturer has devised, and which renders his system truly incomparable. This new feature consists of pipes divided longitudinally by an internal diaphragm into two parts, one serving for the outgo of the water and the other for its return, thereby reducing the length of pipe necessary, by one-half, and considerably increasing the heating surface. On another hand, these pipes are covered externally by numerous pieces acting as heat radiators, rendering their surface of contact with the air of an apartment eight times greater. In the two figures annexed are shown one of these apparatus in perspective and in vertical section. The parts are as follows:

A, Reservoir for fuel.
B, Chimney.
C, D, Dome and water-level.
Z, N, M, Vents in smoke-box for removal of soot
F, Lever for moving the grate, V.
L, Pipe for exit of water.
R, Pipe for return of water.
H, Frame for support of apparatus.
X, Lever for upsetting grate.
K, Tubes forming the grate.
E, Body of the thermo-siphon.

## THE UNDUE DETERIORATION OF BUILDINGS.

THIS subject affects or concerns all that risk money on properties upon which the value is rated with the expectation that the wear and tear will not be abnormal. The changing conditions of manufactures have originated or extended processes which develop fumes and gases disadvantageous to buildings, the health of neighboring persons, and the foliage of trees and plants. Though efforts have been made to disperse or counteract these emissions by tall chimneys, and by utilizing or burning the gases, the difficulty increases beyond the means of relief. The rapid deterioration of some building stones, including marbles, in British cities especially, is well known; and it has been ascertained to be worse where there is most manufacturing, and during the dampest seasons. About fifty years ago, some eminent French chemists made experiments in London which proved the existence in the air there of sulphurous vapors to a very considerable extent, and the difficulty has been constantly increasing in all the British cities ever since.

Almost exactly the same effects are now visible in the cities and towns of the United States, and probably from similar causes, though not so pronounced, because of a drier climate. Most of the sulphurous acid gas in the British and in some American cities arises from the use of bituminous coal containing iron pyrites, which is a compound of iron and sulphur. When the coal is burned, the sulphur combining with oxygen produces sulphurous acid, $SO_2$, and this gradually absorbs more oxygen from the water of moist air, and becomes sulphuric acid, $SO_3$. The climate of Great Britain is, therefore, more liable to the increase of such disadvantage than that of the United States. Of course the acid gases are much diluted by diffusion in the air, but their effects on some kinds of building stone are very marked, even making new buildings soon appear old, with chipped, cracked, or defaced fronts. Under present circumstances such deterioration occurs many years sooner than would have been the result say forty years ago.

Besides the immense extra outlay which was required to preserve the parliamentary and some other principal buildings of London, a more recent evidence of the deteriorating effects mentioned exists in St. Philip's Church, which, surrounded by its cemetery, is near the center of Birmingham —a vast manufacturing locality. The stone of the church walls and the surfaces of the marble tombstones had become so injured and defaced by the acid vapors of the city, that while the inscriptions on tombstones and monuments had become almost illegible, the entire outside of the church required new facing, and other repairs were made from similar cause, the whole necessitating a large expense. In this case it was evidently the vapors from the immense quantities of bituminous coal used in the iron and steel and various other manufacturing works of Birmingham which caused most of the trouble; but it was also increased—as is asserted by Mr. Williams, F.R.A.S., in a late paper in the *Building and Engineering Times*, of London—by the modern extensive use there of "pickling" brass castings, *i. e.*, brightening their surfaces by dipping first in common nitric acid, and then washing in water. This process is attended by the evolution of large quantities of acid fumes, and such mode of treatment of various kinds of castings, etc., and other similar processes, are rapidly increasing in Philadelphia and most of the other cities of the United States.

One of these processes which liberates into the air great volumes of sulphurous fumes is the preparatory cleansing for the so-called "galvanizing," or coating of iron with zinc to prevent rust. The galvanizing establishments have of late years become quite numerous in Philadelphia, and the pungent smell of the gases from such is evident for a considerable distance. An increased number of chemical works and the great extension of those long in existence also add to this difficulty; but in regard to galvanizing, its action is intensified by the fumes not being carried off by tall chimneys nor in any way neutralized or burned. The increasing height of stores, etc., in all the large cities, and the more compact building up of formerly open spaces also prevents the free dispersion of such low-down gases, and consequently augment their deleterious action on buildings.

The defacement of brick fronts, involving really structural injury, through the clouding of portions thereof with powdery sulphate of lime coming from the mortar—the salt being often washed in streaks on bricks and stones below—though considered mysterious by some persons, is clearly traceable to the causes named. In regard to so much of this efflorescence as may form on or from bricks alone, we would remark that clay generally contains some uncombined silicic acid, with variable but small quantities of lime, potash, or soda. The appearance but here and there of this efflorescence is controlled by the quantity of dampness in the walls. This, and the fact that the clouding appears most during the damp months of the winter and spring, confirm what we have stated respecting the sulphurous vapors becoming sulphuric. Where the walls are old and entirely dry, or thickly painted, or covered with mastic, this efflorescence does not appear. Its singular increase in Philadelphia during the past six or eight years is doubtless due to the multiplication of establishments such as forementioned emitting acid fumes, while much more bituminous coal is now burned in Philadelphia than formerly in dwellings, stores, and for various manufacturing purposes, etc. The last remark may the better explain the very extensive development of this efflorescence on parts of the new walls, outside and inside, of the freight depot, etc., of the Pennsylvania Railroad on Filbert street, between Fifteenth and Sixteenth streets, if we consider the fact that bituminous coal is used under the large boilers at Sixteenth and Market streets without any arrangement for consuming the smoke and vapors; also that the appearance of the sulphate of lime is greatest near the upper parts of those new walls.

If this efflorescence was only disfiguring, it would not be within our scope to notice it, but in the lapse of years, and with constant increase of the causes producing it, serious injury must result to many valuable buildings. We have noted instances where the disintegration of mortar extended for a quarter of an inch or more inwards from this reason. Part of the object of these remarks, also, is to show that some building stones, such as serpentine and the granites, are, under present circumstances, less likely to injury than buildings of marble, brown or pictou stone, or even brick. The fact should also be noticed, that if stones or bricks be built with mortar in which a considerable quantity of Teil, Portland, or other cements are used, such mixed mortar resists moisture, and consequently the deterioration from the formation of sulphate of lime.

This view brings forward another cause of injured appearance, which may properly be called undue deterioration, because appearance affects value. The use of black mortar with brick and stone, while safer in such degree as the mortar generally contains some cement, has one serious disadvantage. The lampblack or the powdered charcoal used to blacken, does not yield the permanence of color required for proper buildings. Often in a short time—especially if hard rain storms are driven against such structures—the black particles in the mortar are partly washed out, and a grayish mortar remains. Not only so, but the color, by the influence of the weather, smears the brick, and, much more noticeably, pictou or any light colored stone. There are many unfortunate instances of this in Philadelphia, and some in buildings which are quite new. One notable case is a large and highly ornate corner building, thus injured only a few months after its erection, and to an extent of some thousands of dollars.

Heat will also cause the black color of such mortar to "fly," especially if charcoal be used. We could name as an instance a fireplace in a public institution, where the sides and back were cased with fine brick built with black mortar. Where the greatest heat and the flames from the wood burned touched this mortar it has become quite white, though the upper portions remain black. This teaches that fronts thus built may be injured by the strong heat from burning buildings on the opposite side of a street. We also think it will be found, after some trial, that the novel use of red mortar with red bricks will be subject, though perhaps in less degree, to some of the disadvantages named.

As many modes of manufacture have created new fire risks, and have at the same time stimulated the invention of preventive measures against fire and general means of extinguishment, so some of these interests are now causing undue deterioration in stability of buildings, calling for plans to check the evil. If this be not attended to many persons and corporations may be greatly injured by the depreciation or forced changing of securities or otherwise, and values for insurance be placed upon a false basis.—*Am. Ex. and Review.*

## BUILDING A NEST IN THE WHEELS OF A CLOCK.

THE old clock in the tower of the First Presbyterian Church, Newark, has not been giving correct time lately. Charles Freeman, who is employed by the Common Council to regulate the town clocks, was puzzled by the antics of the ancient timepiece, and when it came to a stop on Monday he decided to give it a thorough examination. In the wheels he found a tangled mass of hay, twine, grass, cotton, and feathers, amounting to nearly half a peck. A pair of birds had entered the tower through a hole in the dial, and attempted to build a nest in the machinery of the clock. The slow revolution of the wheels tore their work to pieces, and they kept on reconstructing it until they stopped the wheels.

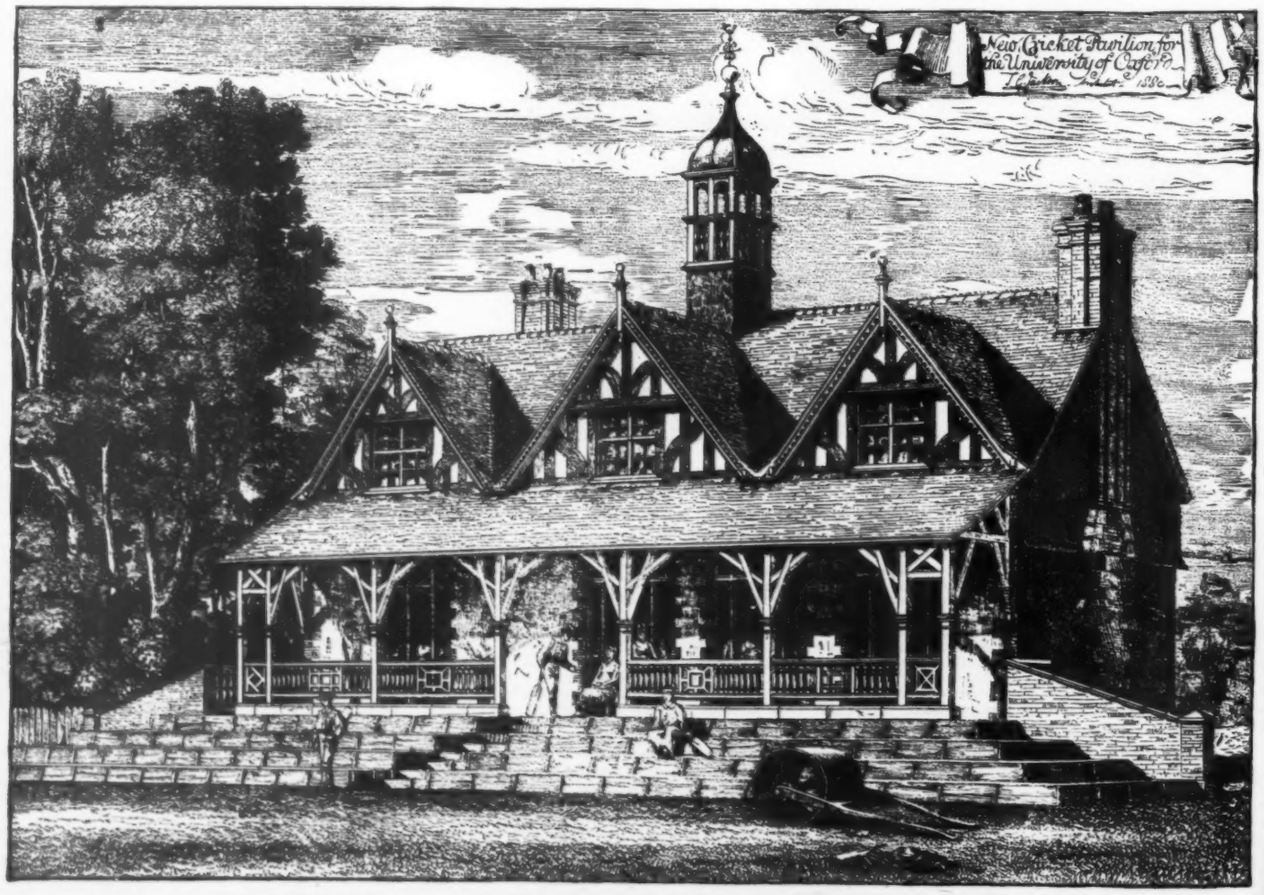
CITY AND GUILDS INSTITUTE OF TECHNICAL EDUCATION, LONDON.

## OXFORD UNIVERSITY CRICKET PAVILION.

THE new pavilion for the use of the Oxford University Cricket Club is built in the Parks, where a new cricket-ground has been lately formed. The building is designed by Mr. T. G. Jackson, M.A., and contains a large dining-room, a bar, with provision for cooking, a committee-room, dressing-rooms for the members of the club, and a room for the players. The principal front faces north to the match-ground, and has four raised terraces for seats, and a veranda, under which is a cellar for keeping the nets and other apparatus of the game. The three gables of this front are of oak timbering, filled in with plaster, and there is a turret for a bell in the roof. The walls are built of rubble stone plastered, with dressings of red brick. The contractor was Mr. A. Estcourt, of Gloucester, and the clerk of works, Mr. E. Long.—*Building News.*

## CITY AND GUILDS INSTITUTE OF TECHNICAL EDUCATION, LONDON.

THE Prince of Wales recently laid, in Exhibition Road, South Kensington, the foundation stone of the central institution of the City and Guilds of London Institute. The ceremony took place in a spacious marquee, upon an elevated dais covered with crimson cloth, in the center of which was suspended a polished Cumberland shap granite pillar, which had to be lowered on to a granite pedestal beneath. We give an illustration of the intended building. It appears from the design of the architect, Mr. Alfred Waterhouse, that the building will have a front of 300 feet, and five stories, all but the top one averaging 15 ft. 9 in. from floor to floor. The entrance will be approached by about sixteen steps from




SUGGESTIONS IN ARCHITECTURE.—OXFORD CRICKET PAVILION.

Exhibition Road, through a large and handsome hall, 37 ft. by 33 ft. 6 in., the groined ceiling of which will be supported by four pillars. There will be two lecture theaters, with preparation-rooms behind them, each capable of holding 208 students; on the first floor there will be a library 37 ft. by 33 ft. Among other provisions for technical or scientific education, there will be chemical laboratories 76 ft. by 50 ft. in extent. The total cost is estimated by Mr. Waterhouse at about £66,000.

The Lord Chancellor, Lord Selborne, on behalf of the Council of the Institute, read an address relating to its history and objects. He observed that twenty-two of the livery companies of the city of London, including nine of the twelve great City Guilds, were represented in the Council of the Institute, and jointly contributed £21,000 annually to its funds. He alluded to the approaching completion of Finsbury Technical College, the foundation stone of which was laid by Prince Leopold in May last, and the foundation of a similar school in Lambeth. He also mentioned the successful efforts of the institute to advance technical education in a large number of provincial towns in the United Kingdom by holding annual examinations in technology, by encouraging in connection with them the formation of evening classes, and by assisting in the payment of teachers, the progress made being shown by the fact that the number of candidates recently examined was 1,563, as against 816 in the previous year. He gave a further description of the advantages to be expected as the result of the foundation of a central metropolitan institution at South Kensington.

The Prince of Wales replied to the Lord Chancellor's address, and bore testimony to the need of supplementing the system of popular education in England by establishing colleges and schools for teaching the principles of science and art involved in our manufacturing industries, which are now exposed to so much foreign competition. He considered that the institution now erected by the City and Guilds of London would be of much benefit to the whole kingdom, as a focus uniting the different technical schools already in existence, and in which, by the aid of scholarships, promising students from the provinces could be brought to profit by the superior instruction that London can command. They would also have the advantage of being near the South Kensington Museum and other valuable collections in London. The realization of this idea was one of the most cherished aims of his father, the late Prince Consort, after the Exhibition of 1851, and the Commissioners of that Exhibition had therefore willingly granted the land for the site of this building. He had much pleasure in accepting the office of President of the Institute.—*Illustrated London News.*

## BUILDING A HOUSE ON A SAND HILL.*

As I am not aware that it has ever before been attempted in the United States to build a house on the very top of a lofty sand hill, exposed to all winds and weather, while simply depending upon, or rather by simply making the loose sand the agent to keep it firmly secured in its seat, I think a few words upon the construction of a single station, which I have just finished for the Maritime Exchange of this city, on top of the highest sand hill at Cape Henlopen, may be of interest to some.

The signal station mentioned will serve to report the arrival at and departure from the Breakwater of all passing vessels to the Philadelphia Maritime Exchange, by means of the Western Union Telegraph lines which connect it with this city.

In the first place, it was necessary that the observer stationed in the building should have a clear and unobstructed view of the seaward horizon from south to north, that is, seaward of the coast line. To obtain this it was necessary to erect the building on top of a hill, which rises some 80 feet above the level of the sea. But the building thus necessarily becomes exposed to every gale that sweeps that part of our coast, while it is absolutely required that it shall stand firmly planted in such a way that even a hurricane shall not shake it or make it tremble, as that would affect the sight of the telescope in the observatory.

The usual mode of securing is by building a foundation of screw piles or of heavy timbers sunk into the sand; the latter mode, however, has this disadvantage, that if the wind shifts the sand away from around the foundation, it becomes undermined and its effect is thus destroyed.

In order to be independent of all this, I designed what I consider a cheap and, at the same time, an effective anchorage for the building in the following manner. The building is of wood entirely; it has a cellar, above which are two rooms, one above the other, and the whole surmounted by the observatory proper. First, the ground-sill is a square of 29 feet, made of yellow pine sticks, mortised together and pinned with stout trunnels. The sill of the observatory is made likewise of heavy timbers, 12 feet long. The two sills are joined together by four stout yellow pine cornerposts, which in turn are mortised into both sills. The posts are 36 feet in length. Five feet above the lower sill is the sill which supports the floor of the first room; ten feet above this is the sill which supports the upper room. Both these sills again are mortised into the cornerposts. This structure is sheathed outside with German siding, inside with rough boards covered with felt, and again by tongued and grooved yellow pine boards. The observatory proper, octagonal in shape, is securely mortised into the top sill, and is covered with a corrugated iron roof, conical in shape. The cellar is floored with 3 inch wood, and boarded all around on the inside of the posts.

I first dug a pit in the sand, about 6 feet deep and fully 20 feet wide on the bottom. I then laid the ground or cellar sill on this bottom, and built the structure; thus the whole depth of the cellar is sunk below the top of the hill, or the level of the sand. I then filled the cellar up solid with sand, and packed it solid all around the outside also; consequently the building is anchored in its place by the load in the cellar, some 100 tons in weight.

I carried three heavy joists (part of the joists which carry the first floor) through on one side of the building, and on these the kitchen was built, so that this is also independent of the position of the sand under it. Since the construction of the station we have had some very severe blows, yet there is no more tremble in the building than if built of stone on a rock.

A few feet from the building stands a signal post or mast 100 feet high, which carries a 5 foot ball of rattan covered with canvas; the ball is made to slide on the mast, and is used to answer signals from vessels by raising and dropping it. As it would, in my opinion, be a rather dangerous thing to simply place the mast in the sand—no matter how deep—I sank a well into the sand-hill.

This well is made of pine, 20 feet deep and 8 feet square. The mast is placed in the center of the well and is braced, from the corners of the pine box, by some 20 stout braces, and the well afterwards filled and tightly packed with sand inside and outside, so that, like the house, to blow it over would necessitate moving of a tremendous weight of sand with it.

* A paper by Mr. J. J. de Kinder, read before the Engineers' Club of Philadelphia.

## PHYSICS WITHOUT APPARATUS.

EXPERIMENTS on the center of gravity are very numerous, varied, and instructive and we have already described a number in former articles. On the present occasion we call

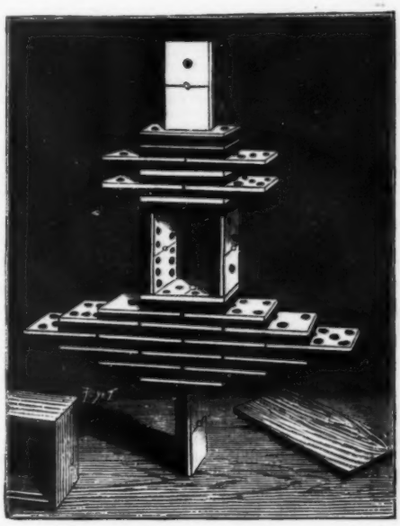


FIG. 1.—EXPERIMENT ON THE CENTER OF GRAVITY WITH DOMINOES.

attention to another one, which is shown in the accompanying figure (Fig. 1). The figure explains itself; it shows how a complete set of dominoes may be supported by a single piece. To facilitate the building of the structure here shown, it is well to begin with three dominoes. After a portion of the structure is completed, the two outside dominoes may be carefully removed and placed on top. Provided the vertical from the center of gravity of the system passes through the base of the supporting domino, the whole will be in equilibrium.

Fig. 2 shows an interesting experiment on inertia, which may also be performed with dominoes, as follows: First, two dominoes are stood on end with their white faces turned inward, then another one is laid across them horizontally. On the horizontal domino a fourth is placed, the black faces in contact. Finally, on this fourth domino two others are stood vertically, then another one across them.

The experiment consists in rapidly ejecting the lower horizontal domino from the structure without disturbing the latter.

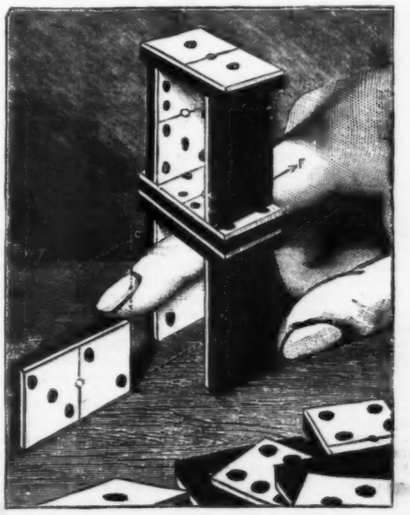


FIG. 2.—EXPERIMENT ON INERTIA WITH DOMINOES.

To do this, a domino must be laid on one of its longer edges, A B, at such a distance from the structure that, on passing the forefinger between the two lower dominoes and pressing strongly on E, the prostrate piece may be abruptly raised to the vertical. If the experiment be properly performed, the angle, D, will suddenly strike the lower horizontal domino and drive it in the direction of the arrow, F; and the displacement of the piece will be followed by the instantaneous descent of the upper part of the structure on the two lower dominoes, which form a support to the whole.

This experiment is so much the easier in proportion as the surface on which it is performed has less polish, and in proportion as the dominoes are thinner and smoother. With very thick dominoes it is almost impossible.—*La Nature.*

## LONGITUDE AND SHIP'S TIME.

THE United States has recently been doing, through Lieutenant Commanders Green and Davis, of the navy, some highly valuable hydrographic work, in determining the longitudes of various ports. The longitudes are fixed by telegraphic exchanges of time signals, the initial point of measurement being the meridian of the Royal Observatory of Greenwich. This method consists in comparing by means of the telegraph cables two chronometers, one situated at either end of the line, and the errors of which on local time are determined by astronomical observations. In this way differences of longitude are first measured from the initial meridian, and then by telegraph from the places so determined, step by step. The French Government has sought to establish a similar set of secondary mediums by observations of moon culminations, but the results do not seem so satisfactory; and the *London Nautical Magazine* says that "experts are agreed that, where telegraphic communication exists, no method of determining longitudes equals, for accuracy and simplicity, that known as the American method." This work of our Hydrographic Office will afford very material relief to geographers and chartmakers, so long embarrassed by conflicting longitude values assigned to nearly all points outside of the United States and Europe, and will take rank with the historic measurement of an arc of the meridian, made by Bouguier and La Condamine, in the valley of Quito, a century and a third ago, which has conferred enduring honor on the French Academy of Sciences, who originated it.

But navigators have to deal with another matter of great concern to them, inattention to which makes the most accurate determination of longitudes of little avail. The testing and correction of ships' chronometers are indispensable to safe navigation, and this work calls for a clear and precise definition of the point or object in each maritime city from which longitude is reckoned. The points selected by Commander Green are conspicuous objects, as the Morro Lighthouse at Havana, the Port Royal flagstaff at Kingston, Jamaica, the center of the dome of the Imperial Observatory at Rio de Janeiro, and the cupola of the Custom House at Buenos Ayres.

. . . An examination of this process of "rating chronometers," as it is called, is quite interesting, as showing the care with which the navigator must keep this invaluable instrument up to the standard of faithful time-keeping. The majority of ships' chronometers, on arriving here, are rated to Greenwich mean time. The rate paper shows the error accumulated and also the daily rate of the time-piece. For convenience' sake, while in port, the ship's chronometer is compared to Philadelphia mean time, but, on the day she clears, it is again reduced to Greenwich time. Thus, suppose on July 1st the chronometer is 0 hours 2 minutes 15 seconds fast of Greenwich mean time, then the time at Philadelphia precisely at noon is 5 hours 2 minutes 53 seconds, which expresses its error for Philadelphia mean time. If, on July 3, the error has increased 4 seconds (which represent a distance of about one mile on the earth's surface in this latitude), the comparison shows a gain of 4 seconds in two days, or an average gain of 2 seconds daily. Thus knowing the rate of his chronometer and its error, and the longitude of a fixed point in Philadelphia and the mean time there, he has the essentials for correct calculation.

It is true most sea captains bring their chronometers ashore and leave them to be rated by skilled horologists while they are in port, partly because during the unloading and loading of their vessels these delicate instruments are liable to injury from the jarring of the ship, and partly because in every long voyage the maltreatment they are apt to receive may affect their reliability, though some masters practice the dangerous economy of rating their own chronometers. But, if the arrangement suggested for having time signals displayed from some conspicuous point in the city, the exact longitude of which is fixed, were carried into effect, an additional safeguard would be provided against the sometimes fatal marine disasters incident to chronometer errors. Whether this plan is fully carried out or not, we should have some clearly defined object to mark our meridian. In the Western Cordillera of the Andes, on the snowy crest of Pichincha, nearly 16,000 feet above the Pacific, the cross still stands, says Humboldt, which served for a signal to Bouguier and La Condamine, in their memorable measurement of an arc of the meridian. An equally enduring mark of the longitude of every important seaport would be a boon to navigators and a geographical guide to all classes.

In reference to the time-work of the Greenwich Royal Observatory, Sir George B. Airy, the Astronomer Royal, in his report, just published, says: "In the first few years after the strict examination of competitive chronometers, beginning with 1856, the accuracy of chronometers was gradually increased. For many years it has been nearly stationary," a fact which he interprets "as showing that the effects of bad workmanship are almost eliminated." If this be the case, there can be but little excuse for errors of shipmasters due to ill-going or misguiding chronometers at sea. But it would very greatly further the interests of chronometric navigation, as Sir George suggests, if the "rates of chronometers, obtained while the ships are actually in voyage," were preserved and submitted to competent horologists.—*Philadelphia Ledger.*

## COMPOSITION FOR RENDERING PHOTOGRAPHIC AND OTHER PRINTS TRANSPARENT.

By ELISHA W. POSTON, of Fort Wayne, Ind.

COMPOSITIONS have heretofore been used for this purpose composed of balsam-fir, castor oil, and alcohol, which give to the picture a sallow yellowish tint, which increases with age, owing principally to the balsam-fir, which is entirely left out in my composition and others added of less color and more stability. It is of great importance that the substances used for rendering the picture transparent should be as nearly colorless as possible, especially in portraiture (for which this compound is particularly adapted), in which the colors, being applied to the back of the picture, show through the transparent parts on the front side, and are affected by any intervening color in the picture, the effect of which is to impair the purity of the colors used. Again, the nature of balsam-fir is such that compounds containing it have a sticky quality (as is the case in the one above mentioned), which renders the cleaning of the surface very hazardous and liable to disturb the surface of the picture, while, on the other hand, my composition is entirely free from such tendency. Therefore, to meet the above requirements, I employ balsam-copaiba, castor-oil, turpentine, sulphuric ether, and paraffine. The use of paraffine is preeminently suitable in such composition on account of its durability and transparency, forming an impervious coating, entirely excluding aqueous, gaseous, and atmospheric

influences, which are the well recognized agents of destructibility, while the turpentine and ether serve as solvents of the same. The balsam-copabia gives body without liability of decoloration, as is well recognized by opticians, who employ it for sealing optical lenses, for which purpose balsam fir was at one time used.

The object of my invention is to produce a composition which, when applied to the picture, will speedily render the same transparent to such an extent that when oil-paints are applied to the back the colors will show through on the other side without impairment.

To carry my invention into effect I procure a picture on paper (photographic or otherwise), mount it on canvas (which has been previously secured to a stretcher) with paste in the ordinary manner, and when dry I apply my composition to both sides of the picture, warm it gently for a few minutes, when it will be found that the picture, together with the mounting, will have acquired the transparency necessary. The face of the picture is then cleaned by rubbing with a soft cloth, when it is ready for painting, which is done on the back with oil colors applied with a brush, in the manner well known to artists.

My composition consists of the following ingredients combined in the following proportions, viz.: balsam-copaiba, castor oil, turpentine, and sulphuric ether, each one ounce, and paraffine, twenty five grains. The turpentine, sulphuric ether, and paraffine are to be combined by gentle heat and agitation before being added to the other ingredients; then thoroughly mingle all together by agitation.

## STREAKS IN GELATINE PLATES.

NEARLY every week some light is thrown upon a hitherto unintelligible cause of failure in the gelatine process, which, by systematic investigation, as well as by careful observation, has already been placed among the most beautiful, and, at the same time, the most certain of photographic processes.

Nevertheless, but few ordinary photographers appear to be in a position to prepare their own plates with the certainty of producing results as good as are obtained from the best commercial plates. True, it is not difficult to obtain both sensitiveness and freedom from fog, if ordinary care is taken, for the conditions necessary to success in these particulars are now comparatively well understood; but still there frequently remains some minor defect, of very obscure origin, which renders absolute perfection so difficult of attainment, that the amateur is often induced to abandon the preparation of his own plates, and, in preference, to adopt the more expensive, but at the same time, the more certain plan of buying them.

For example, it frequently happens that either spots appear on development, or that light streaks and insensitive patches reveal the fact that the film is not of perfectly homogeneous character throughout. Now it has been shown beyond doubt that a most frequent cause of spots is to be traced to dust and to minute particles of foreign matter which adhere to the surface of the gelatine film when in a wet condition. For the microscope reveals the fact that nearly all circular spots on gelatine plates have some nucleus in the center, which has apparently acted as a repulsive agent, preventing the precipitation of silver within the sphere of its influence.

But the origin of streaks and light patches is not so easily traced to any definite cause. The microscope, in this case, fails to detect any apparent difference in the film, and the only conclusion which can be arrived at is, that the particles of silver bromide are in a different molecular condition in various parts of the film. Toward the explanation of one very likely reason for this class of defects, Mr. Warnerke has done good service by his observation of the effects of pressure upon the gelatine film. He observed that, when a number was written in pencil on the back of a sheet of tissue, the pressure thus caused produced, on development, light-colored marks on the film. He next tried the effect of writing, with an ivory stylus, some words on a gelatine plate. After development, the words appeared light on a dark ground. In fact, it was found that a very slight pressure on the surface was enough to produce a marked diminution of sensitiveness, on account of the compression of the gelatine produced by this means. Now, it is beyond doubt that a large number of streaks and patches upon gelatine negatives has been produced accidentally by some similar process to this. It has been generally believed that when once a gelatine plate has been properly made, it will stand any amount of rough handling, so long as the film is not actually scratched or broken. But this observation of Mr. Warnerke's is sufficient to show that the greatest danger may ensue even from a slight rubbing of the film. If touched with soiled fingers it will be readily understood that stains might occur on development; but, hitherto, it has not been generally known that simple contact, even with substances which are chemically clean, may produce most undesirable results.

One simple illustration of the practical application of this discovery will suffice. The tourist who wishes to change his plates, after a day's photography, frequently does so under cover of darkness, and feels the coated side of the glass by passing his finger across it. It is now seen that he will be fortunate if he secures negatives free from some trace of his finger marks. But, probably, in very few cases has any particular care been taken to avoid touching the gelatine; and without doubt many of those hitherto inexplicable streaks and patches which have appeared on negatives, perfect in all other respects, may be ascribed to unintentional compression of the film by accidental pressure. That some spots undoubtedly have this origin is proved by the fact that in some cases an unmistakable, although faint, impression of a genuine finger mark has appeared on development.

But, apart, from the practical importance of the fact that compression of the film produces a local diminution of sensitiveness, this discovery has also an especial interest from a theoretical point of view. Captain Abney long ago expressed an opinion that the greater sensitiveness of bromide of silver in gelatine, compared with collodion emulsion, is not due to any chemical or physical condition of the silver salt, but only to its molecular condition. This theory is borne out by Mr. Warnerke's observations; for he found that expansion of the film, by moistening parts of it with water before exposure, caused increase of sensitiveness.

The true cause of this phenomenon is not perhaps easily explained. Long ago Moser demonstrated the influence of contact upon development. He showed that if a polished surface has been touched in particular parts by anything, it acquires the property of precipitating certain vapors on these spots in a manner different to the untouched spots. Thus, if a piece of metal having a pattern cut out on it be laid for a few minutes upon a piece of clean glass gently warmed, the glass, when cooled and breathed upon, shows distinctly the outlines of the device. But if so slight a cause is adequate to modify the molecular condition of a rigid surface like glass or metal, it can easily be understood that a flexible film like gelatine will have its molecular arrangement disturbed by even the smallest compression.

In the present case, however, the compression appears to retard the precipitation of the silver by the developing agent, not by causing any repulsive action between the particles, but by a real diminution of sensitiveness; for when the film is touched after exposure, no effect is visible.—*Photographic News.*

## CONSUMPTION: IS IT A CONTAGIOUS DISEASE? WHAT CAN BE DONE TO PREVENT ITS RAVAGES?*

By B. COGSHALL, M.D., Flint, Michigan.

A LATE writer has truthfully said: "The most important question now engaging the attention of the medical world is the *contagion or communicability of consumption.*" We may add it is one of the most vital questions affecting the well being of the human race—consequently is worthy of an important place in the discussions of a convention of this kind. This may be readily understood and appreciated when we call attention to the fact that, according to the statements of our best and most accurate statisticians, one-fifth of the human race die of this fearful malady. Therefore, we stand one chance in five of becoming a victim of this fell-destroyer. With these facts staring us in the face we can readily understand that anything which may be said or done in this department of sanitary science that will help clear up this much mooted subject, or shall tend to lessen the ravages of this disease, will be of the most vital interest to us all, as it will add so much to the longevity of the race and proportionally lessen the annual death rate.

It is not our purpose in this paper to enter into a minute or exhaustive discussion of the subject, realizing as we do that papers and discussions in a convention of this kind should be plain and practical and such that the most humble mind can grasp and appropriate.

We shall attempt to give a brief and condensed summary of the most important testimony bearing on the subject, trusting that the discussions which follow will develop and bring out more in detail the many interesting and important points connected therewith.

A few isolated physicians from times immemorial have held to the view that consumption was a contagious disease. Riverius, as long ago as 1638, made the observation that members of a family have one after another succumbed to the disease. Contagion he declared to be the "chiefest" cause of phthisis, "for the disease is infectious."

"We may observe women infected of their husbands, and men by their wives, and all the children to die of the same, not only from infection of their parents' seed, but from the company of him that was first infected." Similar observations have been put on record from time to time since, and yet no general acceptance of this theory obtained, until it was proved by experiments on lower animals that the disease can be communicated. Nor is the matter even yet set at rest, for many able writers and scientific observers contend that the affirmative of the question is not proved.

Villiman, in 1865, claimed to have demonstrated the fact that tuberculosis in any of its products was inoculable.

Tuberculous matter introduced beneath the skin of a rabbit or guinea pig produced tuberculosis. This announcement created quite a sensation in the medical world, and many able observers rushed into the arena, and so-called control experiments were instituted to prove the truth or falsity of this observation. The whole question of the contagion of consumption hinges on its inoculability. If it can be proved that the virus of tuberculosis is a specific poison the question is settled.

Klebs and Villiman maintain the communicability of tuberculosis by virtue of a specific germ, which Klebs has so far isolated as to render it visible under a power of four hundred and fifty diameters, and he says it is quite distinct when the power is raised to eight hundred or one thousand two hundred diameters.

In order to prove the truth of Klebs' assertions, that tuberculosis can be inoculated into animals, Schuller and Reinstadler prepared a fluid now known as Bergman's fluid, in which they propagated the bacteria. These bacteria were introduced into the organism of animals, and invariably produced tuberculosis.

"The question whether there is or is not a specific contagium of tubercle as there is of syphilis or small-pox, has much of pathological interest. But the paramount inquiry for the sanitarian or physician is, Can phthisis, whether specific or not, ever be communicated?"

Dr. Holden obtained in answer to circulars of inquiry, two hundred and fifty replies from leading physicians in various parts of the United States; of these one hundred and twenty-six expressed their belief in the communicability of consumption, seventy four gave a negative answer, and fifty were in doubt on the subject.

Holden says: "Such great lights in the medical world as Galen, Cullen, Heberdeen, Morgagni, Laennec, Andrall, Bright, Addison, Copeland, Drake, Dickinson, Budd, Walsh, Beale, Bodwitch, Flint, Stillé, Da Costa, and others hold to the opinion of its communicability."

The evidence which has produced these convictions in so many minds is of the plainest and most convincing character. A man or woman previously in good health and free from the inherited predisposition to consumption nurses a wife, husband, or friend through a fatal attack of phthisis, and then after a few months, sickens and dies of the same disease. Who of us have not observed this time and again? We record the following case coming under our own observation in the city of Flint, Michigan, it being in the family of M. B., an intelligent and industrious Irishman, whose family consisted of a wife and nine children, who were formerly healthy and robust. On inquiry we found the family record on both sides free from hereditary disease of any kind. About four and a half years ago, one of the sons, a lad of about fourteen years of age, contracted tuberculosis, and after a sickness of about a year died. Soon after this the father, forty-nine years of age, who had previously enjoyed excellent health, sickened, and after lingering a year succumbed. A year later, Jennie, a young lady of twenty-two years, died, after a seven months' siege with this uncompromising enemy of the human race.

On December 6, 1880, another member of this strickened household was placed beneath the sod—Alice, a young miss of fourteen summers, after a nine months' illness. All of these cases were well marked cases of tubercular consumption. Some of the other members of the family have symptoms of the disease. Two of the family have removed to Dakota, where we understand they have regained their former strength, and are now enjoying good health. We are of the opinion that other members of the family will become victims of the disease unless they remove from their infected house, or the virus is destroyed by thorough disinfection. The following case, as reported by Dr. L. G. Bryhn in a Scandinavian journal, will suffice on this point:

"A tuberculous man married a woman of good constitution and family history. The man died and his wife became tuberculous, as well as her sister, who lived with the family during the husband's illness. This sister afterward married a perfectly healthy man of good family history, who shortly afterward became diseased, as did also a niece, who lived with the family for some time. One of their children died of tubercular meningitis, and two more show symptoms of the disease. The woman who nursed the first mentioned man's wife during her illness became tuberculous and died. She infected her sister, who died from the same cause; while their parents lived to old age, and there had been no consumption in their families." He gives other striking instances, and says he "considers the disease *catching*, especially in the advanced stages," and adds: "This is quite as frequent a cause of the disease as heredity."

Dr. Tappeiner, of Neran, in the Tyrol, in a paper read before a meeting of the German Naturalists and Physicians in 1878, says: "All physicians have observed cases of phthisis rapidly developed in individuals who had for a long time attended on patients with this disease, even when such attendants had not presented any predisposition, either individual or hereditary."

The doctor believes that the explanation of the fact is to be found in the inhalation of the expectorated matter scattered in the air by the coughing of patients. In order to test this opinion, he made experiments by intimately mixing a certain quantity of the sputa in a little water; he pulverized this emulsion by an appropriate process and subjected some animals to the inhalation of the substance during one or two hours each day for some time.

Dogs were selected, as they show least predisposition to contract disease. Three perfectly sound dogs were put into a pen in the Anatomico-Pathological Institute of Professor Buhl, of Monaco. The pen was situated near a window and is closed in all parts excepting above, where it receives the external air through a door. Some sputa was obtained from a phthisical patient, a spoonful of which was mixed in a quantity of water sufficient to make it of the consistency of almond milk. For an hour and a half each day, this liquid was pulverized and thrown into the pen. At the same time, for the purpose of studying absorption by the digestive system of the tuberculous matter, two of the dogs were made to swallow a certain quantity of it from the same patient. The five dogs had apparently good appetites, presented neither cough nor diarrhea; they ate freely, and were cheerful and nimble, without any symptoms of illness, unless a slight wasting and arrest of development. At first view the experiment gave a negative result. But the day preceding the first autopsy, a little finely powdered carmine was mixed with the tuberculous matter, in order to discover how far it had penetrated into the respiratory apparatus. Two of the dogs subjected to inhalation, and the two which had swallowed the tuberculous mixture, were killed six weeks after the commencement of the experiments. The results of the experiments were surprising. The five dogs presented a general miliary tuberculosis of both lungs, of the liver, the kidneys, and in the two that had swallowed the tuberculous matter, it was found throughout the digestive apparatus. The numerous stains of carmine which were seen on the pulmonary surface showed that the inhaled liquid had penetrated into the pulmonary cells. The microscopic examination, made by Professor Buhl, established in the clearest manner the reality of the lesions.

It has, therefore, been established experimentally, that in the dog a general miliary tuberculosis can be induced from the inhalation or the ingestion of the matter expectorated by a phthisical patient.

The possibility of the contagion of phthisis through the natural channels may therefore be concluded. The hygienic and clinical consequences of the experiments are of the highest importance. These experiments by such eminent and careful observers ought to be convincing to any one of the communicability of the disease. But we have stronger and more convincing proofs yet to offer.

The following striking case, reported in September, 1878, in a German journal, is to the point, and must count for a strong argument in favor of the theory here advanced. "The only two midwives practicing at Neurenberg, a healthy little town of one thousand three hundred inhabitants in 1875, were R. and S. The woman S. was undoubtedly the subject of phthisis, with abundant purulent expectoration. In the first case described, Dr. Reich extracted the child by turning. While his attention was engaged with the mother, he noticed that owing to some difficulty in the child's breathing, the nurse, S. sucked the mucus from the infant's mouth, and also endeavored to promote respiration by blowing into its mouth. For the first three weeks the child progressed well, but then its health failed, and within three months of its birth it died of well marked tubercular meningitis, initiated by symptoms of bronchial catarrh. In May and June following, two more children died of the same disease. These three cases had been attended by the nurse S. Dr. R.'s attention being thus attracted, he found on investigation that between the 4th of April, 1875, and the 10th of May, 1876, seven children in addition to the above three, had died (all within the first year) of tubercular meningitis, although in no case was there any history of hereditary tuberculosis; that all these cases had been attended by the nurse S., while of all the cases attended by the midwife R., not one had died of this disease, nor had any manifested in any way indications of any tubercular form of disease. The midwife S. herself died of phthisis in July, 1876. It was ascertained that S. had been frequently in the habit of sucking mucus from the mouths of infants, and also of kissing and caressing them."

Perhaps the most conclusive experiments are those of Cohnheim and Solomonsen. They introduced tuberculous matter into the eyes of rabbits, and invariably found it produced first local, then general tuberculosis. The smallest amount of true tuberculous matter introduced through a linear incision of the cornea into the anterior or aqueous chamber of the eye produced in about six weeks an eruption on the iris of minute nodules, which increased to a certain size, then underwent caseous degeneration, to be followed in the course of a month by a more or less general tuberculosis of the lungs, peritoneum, and various other organs.

Of the greatest significance is the fact that these experi-

* A paper read at the State Sanitary Convention at Battle Creek, March 31, 1881.

ments were undertaken in a spirit of skepticism, as Cohnheim was one of the most pronounced and authoritative opponents of the theory of specificity of tuberculous virus, when the theory was first promulgated by Villiman. They observed that the above results occurred regularly whenever true tuberculous matter was used.

After performing these famous experiments, Cohnheim completely changed his former opinions, and is now so thoroughly convinced of the inoculability of the virus, that he proposes to utilize it as a diagnostic criterion of tuberculous products. Harnsell, another famous observer, found that the insertion of tuberculous matter into the anterior chamber of the eye invariably inoculated the iris. The cornea and conjunctiva could moreover be inoculated directly, and in all cases the tuberculous matter inserted disappeared by the third day, and after from fifteen to twenty-three days of incubation tuberculous collections showed themselves.

The fact that these collections or masses were tubercular was proven after the method of the chemist in recognition of the action of poison, that is by insertion into bodies of other animals. Particles were put into the abdominal cavities of dogs and guinea pigs. The dogs died of suppurative peritonitis. The pigs were kept under observation for three months and then killed, when all the internal organs and the skin were found without exception to be filled with deposits of miliary tubercles. Cohnheim tried in vain to excite tubercles in the iris by introducing into the anterior chamber portions of non-tuberculous animal tissues of the most varied kind.

Cohnheim concludes: "Everything depends upon the virus. We discover at all points the closest analogies between tuberculosis and syphilis. Both require above all things infection transmissibility of the disease from person to person."

The comparison between these two diseases we consider well put, for we believe no other infectious diseases so nearly resemble each other. Both, it would seem, depends on a specific virus which must reach a mucous membrane or a denuded surface to be absorbed and induce the disease.

The first symptoms are local in both affections. Both diseases may be transmitted by heredity, and are usually latent for a time in the system. During this latent stage, both diseases impair the processes of nutrition and retard the development of the body.

Professor Whitaker, of the Ohio Medical College, in *Medical Record* of July 24, 1880, says: "While it is true, therefore, of both diseases that they may be inherited, that is, that both syphilis and tuberculosis may affect the ova and spermatozoids as well as every other organ and tissue of the body, it is also true of both diseases that they are in the vast majority of cases not inherited but acquired. A thorough sifting of the cases will show this statement to be notoriously true of tuberculosis as of syphilis. So soon as the inoculability of tuberculosis is established, the fact is also established that the disease is acquired oftener than inherited." He closes his able paper in these words: "The specificity of tuberculous virus is determined in a higher school, and by means more in accord with the principles of science than clinical observation. And the recognition of it clears the field for prophylaxis and opens up a new and more promising *outlook for the therapy of the disease*."

In a late number of the *Medical Record* (March 12, 1880) we find the following abstract of a paper on the tuberculosis due to the inoculation of indifferent substances:

"M. Martin, in a communication to the Societe de Biologie some time since, claimed that the histological structure of tubercle nodules was devoid of special significance, since inoculation with indifferent foreign bodies produces the same anatomical lesions as those obtained with tuberculous matter. The pseudo-tubercular eruptions thus produced in no way differ in their anatomical arrangement from the bodies held to be characteristic of genuine tuberculosis."

Martin then sought to determine whether or not the tubercles produced by the inoculation of tubercular matter differed in other respects from those following ordinary inoculations. He found that the tubercles of tuberculosis possessed the property of infection, whereas the pseudo-tubercles lacked this quality.

It was ascertained that in a series of consecutive inoculations on different animals, the infective properties of the original tuberculous matter was more and more active. In this respect it resembles the virus of septic processes, which Davaine has ascertained to acquire additional virulence with every repetition of inoculation on a new animal. The tubercles of in different substances acted in an *entirely* different manner. No matter how much of such material was employed, the lesions produced were merely local in extent. This was invariably observed. In no case did any tendency to generalizations manifest itself, and not even the neighboring vessels and lymph glands became inflamed or showed tubercular changes.

The non infectious nature of pseudo-tubercles was best shown by attempting serial inoculations. The second animal subjected to inoculation from the pseudo-tubercular matter of the first showed scarcely a local lesion, and the third showed no effects at all. It appears, therefore, that in addition to the true or infecting tubercle, there exists a second kind of granulum, anatomically identical with the former, but totally devoid of all specific properties.

Certainly this is another important contribution to our knowledge of general pathology, and it corroborates Cohnheim's previous assertions concerning the infectious qualities of tuberculosis. Martin is apparently ignorant of the work of Cohnheim, but this makes his results and conclusions all the more valuable, because they were evidently obtained independently of this German pathologist.

In concluding this portion of our paper we may be allowed to state that our views in the main on this important question are well typified in the following cogent propositions promulgated by Dr. Budd, one of the cleverest and shrewdest clinicians who ever lived:

(1) "That tubercle is a true zymotic disease of a specific nature, in the same sense as typhoid fever, scarlet fever, typhus, syphilis, etc., are.

(2) "That like these diseases tubercle never originates spontaneously, but is perpetuated solely by the law of continuous succession.

(3) "That the tuberculous matter itself is (or includes) the specific morbific matter of the disease, and constitutes the material by which phthisis is propagated from one person to another, and disseminated throughout society.

(4) "That the deposits of the matter are, therefore, of the nature of an eruption, and bear the same relation to the disease phthisis, as the yellow matter (the stools), for instance, of typhoid fever.

(5) "That by the destruction of this matter on its issue from the body by means of proper chemicals or otherwise, seconded by good sanitary conditions, there is reason to hope that we may eventually, and possibly at no distant day, rid ourselves entirely of this fatal scourge."

### WHAT CAN BE DONE TO PREVENT ITS RAVAGES?

In order to discuss this important question intelligently, it is necessary to understand by what channels these tubercular deposits reach the system, and how they can be dislodged and thrown off when they have found a lodgment in the body.

From what has been said in the former part of this paper, and the convincing experiments there narrated, it seems to us that it is clearly demonstrated that these specific germs may be conveyed to the lungs and respiratory passages during the act of respiration through the expectorated matter floating in the air, thrown off from the decaying lungs of phthisical patients, and finding a lodgment, a nidus in the mucous membranes, a local trouble is set up which soon invades the lymph glands in the immediate vicinity, and unless arrested at this point the disease speedily becomes general through the contamination of the blood. The experiments and observations of Dr. Grad, veterinary surgeon at Wasselonne, Alsace, on the spread of the disease by contaminated stalls, are very conclusive, and demonstrate the proposition that CONTAGION by CONTACT is possible, and that the extension of the disease by cohabitation is of more general occurrence than is usually supposed.

This fact being established, the question naturally arises, What can and should be done by those dwelling under the same roof, and who are daily brought into contact with friends sick of the disease, and especially those who nurse the patient?

In the first place, they should be very particular to have the air in the rooms pure, by thorough ventilation, in order to get rid of the emanations from the lungs, the impurities constantly floating in the air of the sick-room.

Second, they should be exceedingly careful to avoid inhaling the breath of the sick one. Therefore, they should avoid sleeping in the same bed or in the same room unless thoroughly ventilated. They should frequently go into the open air, and for several minutes at a time, fill their lungs to their utmost capacity with free, pure air, slowly exhaling the same. They should also, by every hygienic measure at their command, keep their system in a good healthy condition, for it is undoubtedly true, that a person in robust health can withstand the debilitating influences of tubercles inhaled into the lungs or taken into the stomach; while a debilitated and partly broken down constitution is a fruitful soil in which these living germs propagate themselves and grow. Then, again, every sick room of this kind should be constantly supplied with efficient and appropriate disinfectants in order to destroy what remaining germs may be left by inefficient ventilation.

Then in case of death of the patient, the house should be thoroughly disinfected by fumigation, the premises renovated, and every sanitary precaution taken to destroy the infectious virus. There is much that might be said in this connection, but want of space forbids.

### DISEASED MEATS.

Another source of infection is undoubtedly through eating diseased meat, or meat infected with tubercle.

Professor Chauveau, of the Lyons Veterinary School, who has for years been experimentally studying the intimate pathology of the various contagia, presents conclusive proof of the transmission of bovine tuberculosis. The success of his researches has afforded some startling results pertaining to the use of diseased meat, and his well designed experiments on cattle have settled among comparative pathologists the question of the virulence of tuberculosis.

The discovery that certain rich virulent matter can infect as readily through the digestive organs as by any other channel, has given him a world-wide reputation.

Two years ago, Professor Colin, of the Albert Veterinary College, contributed a series of observations on the *communicability* of tuberculosis, which were very conclusive and shed a flood of light on this important sanitary question in relation to diseased meat. Many other German and Italian authorities have put on record their clinical experiments confirming the truth of the above mentioned experiments. The celebrated Professor Orth, of Göttingen, has lately published his researches and experiments, from which we extract the following; "He fed fifteen animals with tuberculous matter from a diseased cow, nine of which became infected; of these four died. The remaining five became extremely emaciated, and were killed. On examination nearly all of the organs of the body were found involved in tuberculosis. Consequently the transmissibility of this disease to animals is proved." He insists that its transmission to man is possible, and has undoubtedly many times taken place.

Dr. Cressy, in Proceedings of Connecticut State Board of Health, says: "Nowhere in the struggle of life against the manifold causes of disease, do we more effectually imperil our health and happiness than in partaking of animal food of a suspicious character." He also says: "The meat from cattle affected with tuberculosis is not unfrequently found in our American markets, especially in our larger cities, and even in country towns;" and adds, "I now affirm in a pathological point of view, that the baneful consequences to our health, from the use of infected meat and milk, are not surpassed in the whole catalogue of contagious affections."

Such infected meat, therefore, should not be used; for any organ or texture in which tubercle has been deposited is surely a dangerous article of food. From what is known in relation to the pathology of this virulent malady, we should interdict the sale of consumptive meat and milk, especially in the advanced stages of the disease when the glandular tissues have become involved.

### COOKED MEAT.

The question naturally arises, Does cooking the meat destroy the infectious qualities? On this point, we have the experiments of Professor Gerlach. Solid, fibrous, and broken down tuberculous masses were cooked from one fourth to one half hour, and then fed to five small pigs and ten rabbits in considerable quantities. The result was, that the five pigs and five of the rabbits, two-thirds of the whole number, contracted the disease. In all the experiments with cooked food, the animals were less affected than those fed with raw meat.

From this it appears that tuberculous meat cooked from one-fourth to one-half an hour is still infectious, yet in a less degree than in the raw state. It is probable, however, that long, thorough cooking would destroy the virus.

### TUBERCULOUS MILK.

The recent investigations of Professor Bollinger, of the University of Munich, on the artificial production of tuberculosis as induced by the consumption of diseased milk, are of the greatest importance. He claims that the milk of such animals has a pre-eminently contagious influence, and reproduces the disease in other animals experimented on from that point of view. He believes also that such milk, even when boiled, still retains its injurious properties.

Furthermore, he maintains that beyond doubt the tuberculosis of the human subject, though not completely identical with that of the cow, is yet strictly analogous to it, and that consequently the wide prevalence of tuberculosis in the native herds, at least five per cent of which are affected, is a standing danger to the community.

In speaking of this subject, Dr. Fleming, of the British army, who has given the subject much attention, says:

"There is every reason to *prohibit* the use of milk from cows affected with tuberculosis, and especially for infants who mainly rely upon this fluid for their sustenance, and whose powers of absorption are very active. Even if it did not possess infectious properties, its deficiency in nitrogenous elements, fat and sugar, and the increased proportion of earthy salts, would alone render it an objectionable article of diet. In fact, it has long been known it was liable to produce diarrhea and debility in infants, but though many children fed on such milk have died from tuberculosis, or a localized type of it in the bowels known as *Tabes mesenterica*, the part probably played by this liquid in its production has rarely been suspected.

He further observes, that as the commencement of phthisis is generally so insidious in the human species, it is most difficult to arrive with any degree of certainty at the causes which directly induce or favor its development; but, from the evidence before us, it is to be feared that at least one of its sources must be referred to the utilization of the *carcass*, but more especially to the *milk*, of phthisical cattle as food.

It is certain that tuberculosis is not uncommon, and that it is a destructive disease among *dairy* cattle especially, and more particularly those in towns; that the udder of these animals is one of the glands not *unfrequently* involved; that infants and adults consume milk in somewhat large quantities, and that phthisis is a very prevalent and fatal malady in the human species, and chiefly among the dwellers in towns and cities.

Dr. Bromtey, of Lancaster, England, found characteristic tubercular lesion in the pulmonary organs of two pigs, which had been fed on milk from a consumptive cow; while the mother of the pigs showed no signs of the disease on being slaughtered. Hence, the necessity of guarding ourselves against such a diseased article of food.

Professor Gerlach, Dr. Toussaint, and many other veterinary pathologists have demonstrated, by hundreds of positive experiments, that this milk is *infectious* and contains a *specific virus* that can be transmitted from one species of animals to another, and from animal to man, thus proving the *identity* of this dreaded bovine malady with that in the human subject.

### SANITARY REGULATIONS.

It being satisfactorily proved that the disease may be and often is communicated in this way, it naturally follows that there ought to be some necessary *sanitary regulations*, and sanitary officers to enforce these regulations, in order that we may be assured that our meat and milk supplies are pure and wholesome. There is no doubt but the traffic in this country in diseased meats is quite extensive and calls for appropriate legislation to prohibit it. The public health is involved, and everybody should understand the danger of contracting the disease in this way, and the importance of having competent inspectors to protect our lives from the invasion of disease from this source.

Great Britain has inaugurated this movement, and now has professional inspectors at all the principal commercial points in her vast domain, and recently several important stations for pathological observations have been created by the British government. This government ought to follow close in the footsteps of her illustrious mother and inaugurate and maintain similar stations and officers in this country; then we might expect that very much would be done to assist in preventing the ravages of this great scourge of the race.

### WHAT CAN BE DONE TO DISLODGE THE ENEMY WHEN HE HAS POSSESSION OF THE CITADEL?

In order to properly discuss this subject, more space would be needed than we have at our command. We will only offer a few general remarks in this connection. Up to a comparatively recent period, phthisis was regarded as necessarily a fatal disease and but little was done, and that to little effect, to arrest the disease.

At present, however, it is generally admitted that judicious treatment can, in a vast majority of cases, not only prolong life for months and years, but in many cases a complete cure can be effected, even in advanced stages of the disease.

Dr. John Hughes Bennett, in his admirable work on "Pulmonary Consumption," gives details of the arrest of the disease in its most advanced stages. He says: "I express my convictions that its permanent arrest and cure are, by judicious treatment and hygienic management, becoming every day more frequent and more widely extended."

A study of the pathology of the disease will lead us to the conclusions that *phthisis* is dependent:

(1) On impoverishment of the blood.

(2) On exudation into the lungs or other organs which assume a tuberculous character.

(3) On destruction of the lungs, owing to successive depositions and softening of these.

This being the case, common sense would say our endeavor should be directed to improve the faulty nutrition by every means at our command, to cause the absorption of this tubercular exudation, and to arrest the ulcerative process and prevent a recurrence of the disease.

Bennett says: "The great indication in the treatment of phthisis pulmonalis should be to improve the nutrition of the economy. This does not merely consist in increasing the quantity and improving the quality of the food, but in employing all those means which shall secure—first, an appropriate diet; second, causing its assimilation and the formation of good blood; third, securing the proper purification of it by the atmosphere; fourth, seeing that a proper demand for the addition of new matter to the tissue is created by sufficient exercise; and fifth, that the effete matters be properly excreted from the economy by the emunctories. All these processes are comprehended in the function of nutrition."

Had we time at our disposal, we should like to discuss this subject more in detail under the following heads, Proper diet, sufficient exercise, pure atmosphere, suitable climate, bathing, etc.; but we desist.

In conclusion, allow us to say that we are very certain whoever attempts to arrest and cure the disease in any other manner will meet with disappointment. In this disease more than in any other does the so-called hygienic treatment offer hopes of success. All of our medical treatment should be in subordination to the hygienic. This statement

gives us the opportunity to say that all of the nostrums and so-called consumption cures are of no benefit, but a positive injury not only from their inherent injurious properties, but by trusting in them, much valuable time is lost as well as money wasted. *Pure air*, and plenty of it, is worth more than all the "consumption cures" ever concocted.—*Physician and Surgeon.*

## MERCURIAL FUMIGATIONS IN DIPHTHERIA.

By J. CORBIN, M.D.

"LARYNGEAL diphtheria proves fatal in almost every case, unless tracheotomy be performed." Such is the language of Dr. Jacobi, and I will further add that it too frequently proves fatal where it is performed.

Inasmuch as my paper this evening has reference only to this form of diphtheria, I trust I may be pardoned if, in introducing this subject, I begin first with the individual cases as they have occurred in my practice. In the month of November, 1874, I was called to attend a child, three years of age, with diphtheria, in a family where an older child had just died of this disease. Under the usual treatment of iron and quinine this patient seemed to be doing well until the fifth day, when the hoarse and stridulous cough and aphonia reminded me what I must expect, namely, a fatal result.

Without loss of time I began, in this case, the use of the black oxide of mercury in the form of fumigations, using a half drachm every two hours, and keeping the patient under an improvised tent for the space of fifteen minutes. No other treatment was used, except stimulants and a nutritious diet. On the third day this child expectorated a piece of membrane nearly four inches in length, so that it is fair to conclude that in this case the disease involved the larynx and also the trachea to a considerable extent. From the commencement of the aphonia to the restoration of the voice, it was exactly twenty-one days

The above is a brief history of the first case of diphtheria which I treated by mercurial fumigations. I will here say that I have since had frequent opportunities of using this particular form of treatment, but I was not satisfied whether my case resulted favorably from accident or medication, as we have reports of favorable results from all sorts of treatment; but lately having saved three other children in succession, I have to acknowledge that my skepticism is very much shaken, if not removed.

On the 25th of April last, a child, five years of age, was attacked with diphtheria for the second time—the first attack occurring last November. The membrane was confined to the tonsils. The case progressed favorably until the third day, when aphonia and stridulous breathing occurred. I found this condition on my morning visit, though nothing of the kind was present the evening before. In this case I used the mild chloride—a half drachm every two hours, as the case was very urgent. Drs. Jewett and Hunt were called in consultation, and concluded that tracheotomy should be performed, which was accordingly done by Dr. Jewett at ten P.M. This child had received only four fumigations, and had I felt confident of that plan of treatment, and my patient would have lived till morning. I believe that in this case tracheotomy would not have been required. The case, however, progressed favorably, without further retention of membrane, and made a good recovery,

A second case occurred in the same family at this time—a child three years of age. On the fourth day of the disease the same symptoms were present as in the preceding case. I placed the child in a crib, covering it with a woolen blanket, and began the fumigations, using, as in the preceding case, the mild chloride. I persistently kept it up for one day, when it no longer became necessary. The breathing was relieved, and the child expectorated for a number of days a material which I should judge to have been broken-down membrane. This child is now entirely well. My fourth case is of more recent date, and was more obstinate to control. I used in this case nine drachms of calomel. The child was a girl, eight years of age, where I had the same conditions present as in the preceding ones. The result was a good recovery. Such is a brief outline of the history of four cases of laryngeal diphtheria, which I have treated by mercurial fumigations. I would say they were all of a sthenic type, and I would confine this method of treatment to this particular class. I believe it to be an efficient curative agent. In every case the tonsils only were covered with membrane, excepting one where the membrane extended to one side of the uvula. In this child the glands of one side of the neck were considerably swollen, but there appeared to be no blood poisoning present. When we take into consideration the mortality of this form of diphtheria, I think we are justified in adopting almost any plan of treatment which will save life. I have seen no unpleasant results in any of the above cases. There has been no salivation in any one of them. There has been no diarrhea produced, as there must have been if the medicine had been given by the mouth, which, of course, would have been impossible. In no case was there any particularly marked symptoms of depression or exhaustion. I did not continue the fumigations in any case longer than was necessary to control the disease. A few words in regard to the manner of vaporizing the mercury. I have used in three cases calomel and in one the black oxide. I would prefer the former. The fumes of it are not unpleasant or suffocating. It is always easy, in almost any house, to improvise a tent or a substitute for one. A cane-seated rocking-chair for larger children, and a crib for smaller ones will answer every purpose. Over these a woolen blanket can be spread and removed as required. Under the chair or in the crib a tin alcohol lamp, with three arms to support a piece of tin; on the tin is placed the calomel, when only a moderate heat will almost entirely volatilize it. This arrangement does not demand a great amount of intelligence on the part of the mother or nurse to see that the physician's orders are faithfully executed.

I trust that if any of the gentlemen present should decide to adopt this method of treatment in this particular form of disease, they will begin when it is not too late. It has served me well in the above cases, and my apology for presenting it to you this evening is that I can find no record of this plan of treatment; and if this simple method will be the means of saving life where we usually expect a fatal result, it ought to be publicly known. In my opinion, the action of mercury administered by fumigations is founded upon a reasonably philosophical process. It occurs to me that it strikes at the root of the evil, that it destroys that element in the blood upon which the plastic condition of the membrane depends, and that, having destroyed this, the membrane dies and is soon thrown off. In no other way can it be introduced in a sufficiently rapid manner to control laryngeal diphtheria than by fumigation, without producing deleterious or exhausting results.—*Proc. Med. Soc. Kings Co.*

## BACTERIA AS A CAUSE OF DISEASE IN PLANTS.

By PROFESSOR T. J. BURRILL.

CERTAIN diseases of animals are now positively known to be due to the action of the minute organisms commonly known as *bacteria*. They are spoken of as "disease germs" or "spores," and the "germ theory" of disease is very fully discussed in medical literature. Among the best proved examples that the so-called germs are the actual *cause* of disease, we may cite anthrax in cattle, malignant pustule in man, and the diseases of swine and fowl ordinarily known as cholera.

Many other contagious diseases of man and the domestic animals are scarcely less clearly known to be due to bacteria, but it has not been shown that they also cause disease and death of plants, except as recently announced by the writer in case of "blight" in pear and apple trees (August, 1880, American Association for the Advancement of Science). I

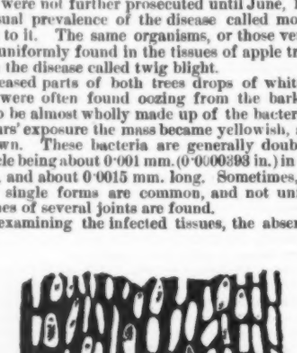
Healthy Pear Bark, showing cells filled with starch. Magnified 125 times.

am now able to add the "yellows" of the peach with much confidence, without, however, the full investigation given to the former disease.

In 1877 I observed in the fluids of blighting pear trees great numbers of minute, moving things, which were not clearly identified as bacteria until the following year. Their presence was uniformly detected in every examination made (and they were numerous) during the summer of 1878, and the fact was reported to the Illinois State Horticultural Society, in December of that year (Transactions, p. 79). Investigations were not further prosecuted until June, 1880, when the unusual prevalence of the disease called more special attention to it. The same organisms, or those very similar, were as uniformly found in the tissues of apple trees suffering with the disease called twig blight.

On diseased parts of both trees drops of whitish, viscid material were often found oozing from the bark, and this proved to be almost wholly made up of the bacteria. After some hours' exposure the mass became yellowish, and finally dark brown. These bacteria are generally double-jointed, each article being about 0·001 mm. (0·00·0393 in.) in transverse diameter, and about 0·0015 mm. long. Sometimes, however, the oval single forms are common, and not unfrequently longer ones of several joints are found.

Upon examining the infected tissues, the absence of the



Diseased Pear Bark, from limb three weeks after blight commenced. Magnified 125 times.

starch granules, so abundant in the healthy cells, was especially marked. Tests revealed the fermentation of this starch with the evolution of carbon dioxide, hydrogen, and butyric acid. The other carbonaceous materials in the cells, as sugar, malic acid, etc., doubtless undergoes the same fermentation, but being soluble in water their loss is not rendered evident by the microscope. The cell walls, contrary to my expectation, were not found injured, neither was the protoplasm involved in the fermentation.

By passing a thin section of the bark under the microscope it is possible to find in the same slice all variations, from perfectly healthy cells to those which have lost the whole of the stored starch, the bacteria likewise varying in numbers as the destruction of the starch bacteria progresses. How these originally gain entrance to the cells was not made out. There are certainly no pores or other visible openings through which they pass. Water, however, is absorbed by the cell walls, and passes through their molecular spaces in all directions.

It may be that in the germ condition the bacteria are really small enough to pass with the water through the walls, notwithstanding the fact the highest powers of our microscopes fail to detect the molecular openings. However this may be, it is positive enough that the adult bacteria do not in this way traverse the cell walls. The evidence is totally against any distribution of the organisms in the tissues by the circulations of water or sap. They slowly make their own way from cell to cell, progressing equally in all directions from the starting point, when the same conditions are presented.

On July 1, 1880, I inoculated two pear trees by inserting small pieces of bark from a pear tree in which the disease was in active progress. On the 12th and thereafter, inoculations were made by dipping a clean needle or the sharp point of the blade of a penknife into the viscid substance exuding from diseased bark, diluted or not with distilled water, and thrusting the instrument into the experimental trees. Usually three such punctures were made near each other, but the three were counted as one inoculation.

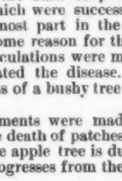
No visible results followed any of these inoculations during the first eight days, and in some cases for two or even three times this period. In the majority of cases ten to twelve days elapsed before external signs of the disease could be observed. No difference was detected in this or any other respect in the different ways of inoculation. But numerous external applications of the virus were made to the bark and leaves without wounding, none of which seemed to communicate the disease. The trees were examined at least once each day until the 14th of August, 1880, and every observed change carefully noted. Very often the disease could be detected by dissections and microscopical examinations when no external indications were presented, but these were not counted as successful inoculations except in very clear cases.

The experiments upon pear trees were made upon trees three years old, Bartlett and Clapp's Favorite, seventy-two in number. The apple trees are Grime's Golden, and the quince, Angers. The following table gives the results in per cents of the number of successful inoculations:

| Number of Experiments. | Kinds of Trees | Virus from Pear. | Virus from Apple. |
|---|---|---|---|
| 36 | Pear | 54 | 72 |
| 29 | Apple | 30 | Not tried. |
| 4 | Quince | 100 | Not tried. |

It will be observed that the virus from the diseased apple limbs was more fatal to the pear than that from blighting pear, showing at least that the disease in the apple is of the same nature as that known as fire blight in the pear. It is quite possible, however, that the greater percentage is due to other causes than the virulence of the inoculating material, and that another set of experiments would show this. The low percentage in case of the apple (30) inoculated with pear virus is partially explained from the fact that ten inoculations were in the bark of portions more than one year old, none of which were successful. As these trees show blight for the most part in the shoots of the current year's growth only, some reason for the failure may be conceived. But four inoculations were made in the quince, all of which communicated the disease. These were made upon the young shoots of a bushy tree which was not otherwise unhealthy.

Since these experiments were made, careful study has convinced me that the death of patches of bark on the trunk and larger limbs of the apple tree is due to the same cause. The disease slowly progresses from the center of infection,



Blight Bacteria. Magnified 1,000 times.

and kills the tree when the whole circumference becomes involved. Sometimes, however, the liber (the bast cells are not penetrated by the bacteria) forms a complete shield to the inner tissues, and after the outer cellular bark is destroyed a new layer is formed beneath, the old finally falling away.

Meteorological conditions probably have some influence, but how much and what is not clear. The disease slowly progresses in winter as well as summer, in dry weather as well as wet. The sudden appearance often noted is but the blackening of the leaves upon a branch long diseased.

The slow progress of the malady gives the best hope for successful treatment. It has been considered sudden and irregular, with little or no indications of trouble until destruction came; but this is greatly over stated. Acquaintance with the first appearance in the bark, and careful examination every two or three weeks, will make treatment much more possible than heretofore supposed. The remedy proposed is the old one of cutting away the diseased portions, adding, however, the precaution of taking all infected parts, and not merely such as have become blackish after the ravages are complete, and to observe requisite care in cleansing the knife or other instrument, that by the very process of cure the contamination is not spread. Probably carbolic acid or other antiseptic washes may be useful, but proof from actual and indisputable experiment has not yet been reached.

Very recent examinations of material sent from Michigan conclusively confirms my opinion that the yellows of the peach tree is caused by a similar organism. In the cells of an infected shoot I find very little stored starch, but numerous bacteria. These are seemingly different, under a one-tenth Tolles' or Spencer's objective, from the bacteria of the pear and apple. Compared with the latter, they are long and slender, measuring about 0·001 mm. by 0·0035 mm. They consist of several joints, but little longer than wide in what appears to be the typical forms.

The Lombardy poplar trees are also destroyed by these ferment producing agents, following the attacks of certain wood-boring coleopterous larvæ. The latter penetrate the bark and take devious courses through the bark parenchyma and the cambium layer. Starting from their channels, the bacteria slowly spread from cell to cell, until so much of the essential tissue is destroyed that the tree, after some years of hopeless struggle, succumbs. Sometimes the bacteria collect in immense numbers in pockets, which they appear to form in the bark of this tree by absorption of the cell walls. The thick, white mass which they thus form has the appearance to the unaided eye of pus from sores in the flesh of animals.

The aspen (*Populus tremuloides*) is similarly affected. The young limbs die and the leaves become black in a manner every way similar to those of the pear and the apple.—*American Naturalist.*

## THE SUCCESSFUL ADMINISTRATION OF NITROUS OXIDE FOR DENTAL AND SURGICAL OPERATIONS.*

THE successful administration of nitrous oxide consists in administering it to patients in such a manner that, during operations, the patient will not suffer pain, and that the patient will be in such a condition that the dentist and surgeon can successfully perform the operation, and afterward that the patient is found not to be injured by its administration.

The first requisite for success requires the nitrous oxide not to have more than one per cent of pure oxygen or three per cent of atmospheric air, and that it should be perfectly free from all other gases or vapors. Nitrous oxide, with two per cent or more of oxygen, or five per cent or more of atmospheric air, will not produce perfect anæsthesia, and the patient will feel the pain of the operation and pronounce the gas a failure. The adding of one per cent of pure oxygen to nitrous oxide has the benefit of partially oxygenating the blood, and in a measure preventing the spasmodic action of the muscles and at the same time produce satisfactory anæsthesia.

According to experiments made in France by P. Bert, ten per cent of oxygen or fifty per cent of atmospheric air can be added to nitrous oxide to oxygenate the blood, and at the same time produce perfect anæsthesia if it is breathed in a chamber under a pressure of two atmospheres. A certain amount of nitrous oxide taken into the lungs is necessary to produce insensibility, and it can be diluted with any innocuous gas, and still produce anæsthesia, provided this amount is inhaled in the given time. Under pressure in a chamber more gas is breathed in a given time, as the nitrous oxide is condensed the same as the air in the chamber, and under a pressure of two atmospheres two volumes of nitrous oxide would be condensed into one volume, so that the nitrous oxide could be diluted with equal measures of atmospheric air, and still the quantity of nitrous oxide inhaled would be the same as if breathed ordinarily, and the quantity of oxygen breathed sufficient to arterialize the blood.

Rapid breathing of nitrous oxide produces quick anæsthesia, but nothing is gained by it in practice. It is very difficult to produce anæsthesia with nitrous oxide at high elevations above the ocean, because the low pressure of the atmosphere allows the gas to expand, so that a less quantity is taken into the lungs in a given time than is required to produce insensibility.

Valve inhalers have generally proved a failure, because they admit atmospheric air with the gas in sufficient quantity to prevent perfect anæsthesia. As near as I can ascertain, more than one-half of all the dentists of the United States who have used nitrous oxide have abandoned its use on account of want of success in producing satisfactory insensibility, and thereby injuring instead of benefiting their practice.

One cause of failure is the unskillful administration of the gas in allowing air to be inhaled with it, by not having the lips closed tight around the inhaler and other causes, not using the nose as a valve for expiration exactly at the right time, not stopping the administration at the point of greatest anæsthesia, and not having sufficient self-possession under all circumstances and emergencies to know just what to do and when to do it. But the greatest cause is the failure of producing perfect anæsthesia from the mixture of atmospheric air in the nitrous oxide that has been kept in a gasometer over water for a few days. The gas becomes mixed with air through the medium of the water and defective gasometers and cocks.

The trouble and cost of making fresh gas every few days have caused the great abandonment of its use. Skillful administrators who have a large practice and make fresh gas before deteriorated by air are making nitrous oxide a success. Other dentists can make gas a success by obtaining it condensed in cylinders, when the gas will keep unadulterated and unchanged for years.

The only drawback to a paying success is the present great cost of the condensed gas, which in the small cylinders amounts to about thirty-five cents for each administration, when the gas can be made in the dentist's laboratory for about three and a half cents for each administration. An apparatus can now be obtained that enables each dentist to make and condense his own gas and keep it for any length of time.

Physicians and surgeons do not use nitrous oxide, on account of the trouble and cost of making and keeping it, and the greater amount of practice and skill required in its successful administration than the more dangerous ether and chloroform.

Nitrous oxide requires a costly apparatus to manufacture it and bulky receptacles to hold and administer it from, and the gas is not for sale in but two places in the United States, while ether and chloroform can be carried in a bottle in the pocket and purchased at every drug store in the land. Nitrous oxide can be administered with almost absolute safety, while ether and chloroform can point to its victims in every city and hospital.

Money, labor, and skill can make nitrous oxide successful with both dentist and surgeon, and in judging of the value of human life, nitrous oxide should stand at the head of all anæsthetics, and its practical use be encouraged instead of ether and chloroform.

I have administered nitrous oxide in over thirty thousand cases for dental and surgical operations, and have had uniform success. I have never had a case of injury from lung or heart disease, but in many cases of throat and lung diseases a marked and permanent improvement. I have kept a large number of patients perfectly anæsthetic for surgical operations from five to thirty-five minutes, and the pulse during these operations has been nearly uniform and full. The success of prolonged operations consists in first producing perfect anæsthesia, and then breathing air to arterialize the blood, and before consciousness returns again breathing nitrous oxide, the necessary intervals varying in different patients from one-fourth to one-half minute. The average length of time occupied in dental operations from the first commencement of breathing the gas till return of consciousness has been two minutes.

To encourage and make nitrous oxide a greater success in the future, the dental and medical colleges should employ successful operators to lecture and instruct graduates, so that the particular knowledge and skill acquired by them in practice can be learned by others.

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* A paper read before the American Association for the Advancement of Science at Cincinnati, O., August, 1881.

## CATCHING COLD.*

By DR. CARL SEILER, of Philadelphia.

IN the February number of the London *Lancet* (American edition) will be found a short article on the rationale of cold catching, which in a few words says a great deal which it would be well both for the physician and the layman constantly to bear in mind. I shall, with your permission, quote from the article, which I am sorry does not bear the name of the author, and use it as a text for this paper.

I quote: "Practically the human organism must be maintained at a temperature equal to 96·5 degrees Fahr., in all climates. The source of this heat is within us, and we wear clothes to minimize the expenditure of this heat by radiation."

About the first part of the quotation I have nothing to say, except that 96·5 is rather a low average normal temperature for the human body, and it is generally estimated to be about 98 degrees Fahr. The second proposition, that the source of heat is within us, requires some explanation. Heat is produced in the animal organism in two ways: first, by oxidation of food, and, second, by the conversion of muscular movement into heat, according to the now well established law of the correlation of forces. How and where this oxidation of food takes place I will not here enter into, but will state that certain articles of food yield a larger amount of heat than others. Thus animal food, and especially animal fats and oils, produce more heat when introduced into the system than farinaceous food and fruits do. This we find exemplified in contrasting the mode of living of the Esquimaux and other inhabitants of the north with those dwelling in the tropics.

The Esquimaux lives almost exclusively on animal food and fish oil, while the South sea Islander, who lives most of the time in an atmosphere the temperature of which is higher than the normal temperature of his body, eats chiefly fruits and vegetables. And even in temperate climates, where man lives both on vegetable and animal food, more of the former is consumed during the warm season, while the latter is in preponderance during the cold winter months. The Catholic Church has long ago recognized this fact, and has introduced the Lenten Season, a period of abstinence from animal food, at a time of the year when the seasons change from the cold to the warm, for if more heat-producing food is taken into the system than is required to keep the body at the normal temperature, the digestive system is taxed beyond its capacity, the blood is overcharged with effete material, which is not eliminated quickly enough, and as a result, we feel out of health, which, when it occurs during the first warm days of spring, we call spring fever. The same effect is produced when we change our abode from the North to the South during the winter months, and persist in the same mode of living, and take the same amount of animal food; and if we continue to live this way for a length of time, the result is congestion, and may be abscess of the liver. This is exemplified by the fate of so many Englishmen who go to India, where they eat their roast beef and drink their heavy ales, as they have done in England, but who in a few years have to return with a diseased liver, blaming the climate when they should blame themselves.

In order to oxidize the food, oxygen must be introduced into the system in sufficient quantity, through the lungs, otherwise part of the food only is burnt up and produces heat, while the rest is thrown out again as waste material, and by its presence materially interferes with normal action of the different organs.

Muscular exercise, as is well known, produces heat within the system by a conversion of motion into heat, but this motion depends for its sustenance upon the contractile force of the muscles, which is kept up by part of the food taken into the system. If this contractile force of the muscles is not exercised, it needs not as much nourishment, and the surplus is deposited as fat within and around the different organs. This is exemplified by the fact that in order to fatten an animal, it is kept confined within a narrow space and is overfed.

There can be no doubt that sunlight plays an important part in the oxidation of food within the system, and this is probably one reason why night air is generally supposed to be injurious to delicate constitutions.

This heat, which is generated within the body by the oxidation of food and by muscular movement, would be lost by radiation if the temperature of the atmosphere surrounding the body is far below the normal temperature of the body, and, therefore, this loss must be minimized by interposing between the integuments of the body and the air non-conductors of heat, in the shape of clothing, not to keep the cold out, but to keep the heat in. The face, part of the neck, and the hands are, however, generally exposed, and thereby the epidermis becomes hard and horny, thus becoming a bad conductor of heat, and very little of the systemic warmth is lost by radiation from these parts.

The hydrometric condition of the atmosphere, irrespective of temperature, has a great deal to do with the temperature of the body, at least as far as individual sensation is concerned. We feel more chilly in a cold, damp atmosphere than in a dry one of the same temperature, and we can endure a greater amount of heat when the air is dry than when it is filled with aqueous vapor. As far as I know, this fact has not, as yet, been satisfactorily explained, and I would suggest, as a reason, that the moisture is absorbed by the skin, thus making it a better conductor of heat and facilitating the ingress and egress of heat through it.

We also minimize the expenditure of animal heat by living the greater part of our time (in cities at least) in houses and apartments from which the outer air is excluded as much as possible, and the atmosphere of which, during the cold season, is artificially heated.

The maintenance of the normal temperature of the body, therefore, depends upon the production of heat by oxidation of food within the system, by muscular exercise, and upon the prevention, or at least reduction, of the radiation; and a lowering of this temperature, especially if it be sudden, causes contraction of the capillaries in the outer integuments, a disturbance of the heart's action, and a congestion of some of the internal organs, and particularly of the mucous membrane of the respiratory tract.

Taking it for granted that at a given moment there is a certain quantity of blood in the body which is distributed throughout the vascular system, a greater amount of blood than is normal will accumulate in some portion of the system when a contraction of the capillaries in an area of the surface takes place. Such an accumulation causes an overdistention of the capillaries, and consequently a congestion of the part. As examples of this may be cited the facts that deep seated inflammations, or congestions, are relieved by counter irritation of the skin, and it is by no means necessary to apply the counter-irritant directly over the organ affected to obtain the desired result; and also, that frequently inflammation and even ulceration of the bowels are a result of extensive burns and scalds of the skin, of the chest, or abdomen. In this latter case the capillaries of the skin are violently contracted and the blood driven to other parts of the body, and especially to the intestines, causing a congestion, followed by inflammation of their mucous membrane.

In connection with, and perhaps caused by, this contraction of the capillaries of the skin by cold there is always an irritation of the distal nerve ends, which, by reflex action, produces a change of the heart's action, which in turn becomes a factor in the production of the congestion in other portions of the body.

The blush of shame is produced by reflex nervous action, the cause of which, however, is central and not peripheral, and not unfrequently is congestion of the lungs produced by violent or long-continued emotional disturbances. The reason why the mucous membrane of the respiratory tract is more liable to be the seat of this congestion than any other portion of the body must be looked for in the fact that it, among civilized nations, is hardly ever free from irritation in one or the other portion of its extent. We constantly inhale particles of vegetable and mineral substances in the shape of dust, which, by engaging the cilia of the epithelium, act as irritants. This, together with the impure air surcharged with carbonic acid which we breathe in the confined atmosphere of our dwellings and public halls, produce a want of tone in the mucous membrane of the respiratory tract and its capillaries, thus predisposing it to congestion. For as all fluids, so will the blood in the body when pressed upon at any particular point, seek an outlet at the point of least resistance; in this instance the capillaries of the mucous membrane of the nose, pharynx, larynx, trachea, and lungs. Catching cold may then be defined as a momentary lowering of the temperature of the body by external influences, which causes both directly and indirectly an uneven distribution of the blood and thereby a congestion or inflammation of internal organs.

Here the question may be raised: Why is it that some persons are more liable to catch cold than others, who, perhaps, are more exposed to cold and the inclemency of the weather?

In order to answer this question I must state that the power of producing heat in the system may be weakened by a number of causes, and that when thus weakened it is not able to produce an extra amount of heat when demand for it is made by exposure to lower temperature. Thus we find that a person who leads a sedentary life and confines himself in an atmosphere artificially heated to from 75° to 80° Fahr., accustoms his system to habitually produce little heat, because little demand is made for it; or one whose digestive apparatus is out of order will not properly digest his food, and can, therefore, not produce sufficient heat by oxidation of the food; or one who is deprived, voluntarily or involuntarily, of the necessary amount of oxygen, be it by being confined in close rooms or on account of disease of the lungs; or finally, one who does not take exercise, and so does not produce heat by muscular motion, will easily take cold from the slightest exposure. While on the other hand a person who lives an out-of-door life, and thus exercises his heat producing faculty, takes cold but rarely, even when much exposed.

To prevent taking cold, therefore, a person should take outdoor exercise at all seasons and in all kinds of weather, should not dress too warmly, should have plenty of fresh air in his house and especially in his bedrooms, and should not heat the air in his rooms above 68–70° Fahr.

There remains much to be said in regard to this interesting subject, but the few hints which I have thrown out have already made a longer paper than I had intended, and I shall therefore close by inviting discussion on it.—*Med. and Surg. Reporter.*

* Read before the Philadelphia Laryngological Society.

## OCULAR SYMPTOMS IN DIFFERENT DISEASES.

DR. GORECKI, as quoted in the Glasgow *Medical Journal*, has tabulated his views as follows:

Blepharoptosis, or the falling of the upper eyelid, indicates paralysis, complete or incomplete, of the third pair.

Lagophthalmos, or inability to close completely the palpebral fissure, is a sign of facial hemiplegia, idiopathic or a symptom of cerebral disease.

Strabismus occurring suddenly, and accompanied by diplopia, is most frequently the result of some cerebral affection.

Xanthelasma (a yellow lamina sometimes met with in the skin) of the eyelids, occurs in certain alterations of the liver.

Sub-conjunctival ecchymoses are frequent in whooping-cough, and may sometimes, at the beginning of the complaint, clear up a difficult diagnosis.

Redness of the conjunctiva, watering of the eye, etc., indicate in the child the outbreak of some eruptive fever, particularly measles. The prognosis is favorable if the tears come when the child cries, but fatal if the secretion of the tears is arrested.

Spots on the cornea are often the indication of a strumous constitution.

Dilatation of the pupil, or mydriasis, indicates excessive fatigue, the existence of intestinal worms, meningitis in the second stage, or a true amaurosis. The dilatation is most frequently connected with atrophy of the optic nerve. It is seen also during an attack of epilepsy, on coming out of chloroform, after belladonna poisoning, etc.

Unequal dilatation of the two pupils points to the onset of general progressive paralysis.

Contraction of the pupil is one of the early symptoms of *tabes dorsalis*. It is met with also at the beginning of meningitis, in opium poisoning, and in the first stage of chloral poisoning.

Deformation of the pupil, particlarly after the injection of atropine, indicates an old iritis, in nine cases out of ten, of syphilitic origin, if not depending on some disease of the neighboring parts.

Cataract in subjects under say forty or fifty, is frequently of diabetic origin, and constitutes soft cataract.

Finally, the ophthalmoscope enables us to recognize the retinitis of albuminuria in Bright's disease, of simple polyuria, and sometimes in the case of women during pregnancy. Retinal hemorrhages, œdema of the retina, and embolism of its central artery, are sometimes met with in organic affections of the heart. Optic neuritis and perineuritis and atrophy of the disk are symptoms of syphilis, or of tumors in the neighborhood of the cerebellum or the *corpora quadrigemina.*

## THE MOVEMENTS OF PLANTS.

By the Rev. GEORGE HENSLOW, M.A., F.L.S., F.G.S.

THE old distinction between plants and animals, that the latter can move and the former cannot, has long since been abandoned as unscientific, and only lingers as a copy book assertion; but that all plants, even when permanently fixed to the soil, have their stems, leaves, flower stalks, etc., in almost perpetual motion, is a discovery of quite recent times, and notably due to the investigations of Mr. Darwin. His latest work, which bears the title of this article,* is a treatise based on the most careful and elaborate experiments on the motions effected by the different organs of plants; and it was thought that a brief exposition of the chief of these, as well as of some movements peculiar to the parts of flowers not alluded to by Mr. Darwin, might be interesting to the readers of the *Popular Science Review*.

The majority of the movements can be embraced under the single term *circumnutation* and its modifications; it signifies a "bowing around." The stem, leaf, or other organ, when circumnutating, bends to all points of the compass successively, with a sort of rolling motion, so that the side which is uppermost in any direction becomes lowermost when it points in the opposite one. The circles or ellipses thus described by the apex of the organ, are most perfectly seen in the circumnutation of the stems of climbing plants; other organs for the most part move in ellipses, but with frequent interpolations of zigzigs, triangular loops, etc. The *projections* of such motions, when observed for some hours, exhibit most complicated and intricate lines; a great number of these projections are given by Mr. Darwin. With regard to the cause of circumnutation, Mr. Darwin says that on the whole we may at present conclude that increased growth, first on one side and then on another, is a secondary effect; and that the increased turgescence of the cells, together with the extensibility of their walls, is the primary cause of the movement of circumnutation.†

It will be advisable to treat of the different organs in a definite order, so I will proceed to describe the motions of radicles, cotyledons, hypocotyls, and epicotyls of germinating seeds; then will follow those of the stems and leaves of fully developed plants; and finally, the movements effected by the different organs of the floral region.

RADICLES.—The tip of the radicle, as soon as it protrudes from the seed coat, begins to circumnutate, and the whole growing part continues to do so, probably for as long as growth is maintained; it presumably is aided by this motion in being guided along lines of least resistance. As soon as the radicle has protruded, *geotropism* at once acts upon it. If this force be identical with gravitation, it is gravitation acting in a peculiar way; for although the radicles of germinating seeds, whether in England or at the Antipodes, point to the center of the earth, yet the influence affects the tip only, for a length of no more than the 0·02 to 0·03 of an inch, at least, in the cabbage.

This minute part, however, at once communicates some influence to a point further back, where the radicle bends downward in response to it; neither geotropism nor circumnutation can enable the radicle to penetrate the soil. This is effected by the force due to growth both longitudinally and transversely. By means of ingenious contrivances, seeds were grown under resistance; and Mr. Darwin found that transverse growth exerted a force, after six days, of more than 8 lb., and vertical growth, after twenty-four hours, of at least a ¼ lb. The *purchase* for the due effect of these forces is gained partly by the seed being below the soil, aided by the roothairs, which, in consequence of the cellulose passing into a gum-like substance, fix the radicle to the particles of the soil. The growing part, therefore, acts like a wedge of wood, which while slowly driven into a crevice, continually expands at the same time by the absorption of water; and a wedge thus acting, Mr. Darwin observes, will split even a mass of rock.

Another important property of radicles is their extreme sensitiveness to irritants, such as mechanical obstructions, caustic, and injuries by being cut, all of which induce the radicle to *bend away* from the exciting cause, as well as to the presence of moisture, which, on the contrary, induces the radicle to *bend toward* it. Any solid body which gives rise to a permanent obstruction to a radicle, causes the latter to deviate from its path till it finds no great resistance; and Mr. Darwin observes that this is the only known instance of an organ turning *away* from an irritant. By fixing cards to one side of the tips of vertically growing radicles, they were caused to tend upward, as if trying to escape from the cards, sometimes even forming complete circles, and in one case a radicle actually tied itself into a knot (Fig. 3‡). The tip in the act of forming a loop, generally rubs against the upper part of the radicle and pushes off the attached card; the loop then contracts or closes, but never disappears. The apex afterwards grows vertically downward (Fig. 2). This sensitiveness is confined to the tip for a length of from 1 mm. to 1·5 mm., while the upper adjoining part of the radicle, for a length of from 6 or 7 to even 12 mm., is excited to bend away from the side which has been irritated. After a time the radicle apparently becomes accustomed to the irritation, as occurs in the case of tendrils, and the irritant no longer affects its downward growth, which is resumed.

After a radicle, which has been deflected by some stone or root from its natural downward course, reaches the edge of the obstacle, geotropism will direct it to grow again straight downward; but geotropism is a weak force, and the radicle assists it by having its upper part, a little above the apex, sensitive to contact, but acting in a directly opposite manner to that of the tip, for it causes the radicle to bend like a tendril *toward* the touching object, so that as it rubs over the edge of an obstacle it will bend downward. This downward bending coincides with that due to geotropism, and both will cause the root to resume its original course.

Finally, Mr. Darwin observes, the several co-ordinated movements by which radicles are enabled to perform their proper functions are admirably perfect. In whatever direction the primary radicle first protrudes from the seed, geotropism guides it perpendicularly downward; the radicles emitted from the primary are, however only acted upon by geotropism in such a manner as to cause them to bend obliquely downward, unless the end of the primary radicle be cut away, then the secondary ones grow vertically downward. The tertiary radicles are not influenced by geotropism; hence all the rootlets grow in the most advantageous manner, and the whole soil is thus closely searched.

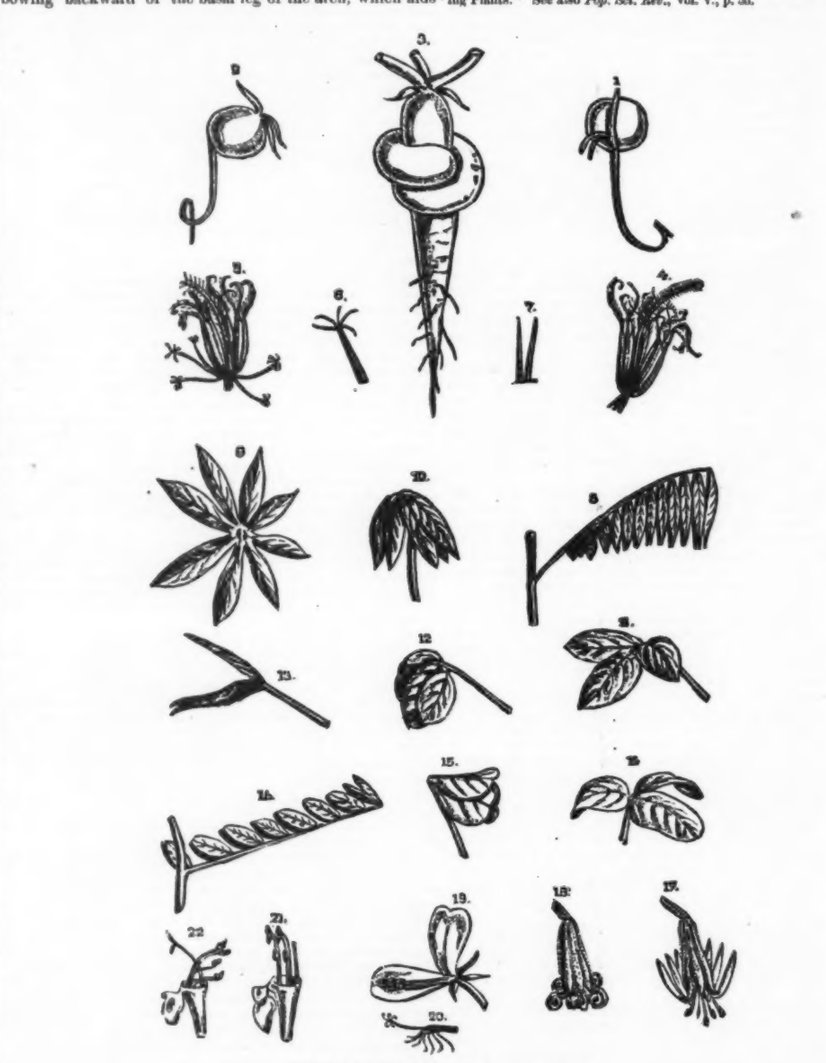
HYPOCOTYLS AND EPICOTYLS.—The radicle having penetrated the soil, the hypocotyl, as the axis below the cotyledons is called, begins to develop, at least in those seeds which elevate their cotyledons above ground; but it is the plumule or epicotyl which alone does so of seeds which retain their cotyledons below the soil. In either case the organ commences its growth in the form of an arch, such being the result of an innate tendency in the case of the plumule to assume that form; the inner concave surface then growing more rapidly than the outer and convex, tends to raise the summit of the arch out of the ground. The apex of the stem, being ultimately freed from the soil, soon straightens itself and becomes erect.

In whatever position the seeds may lie, *apogeotropism* acts upon the arch, and the two legs become vertical; the entire arch circumnutates more or less the whole time as the nature of the soil permits. Mr. Darwin aptly compares the whole process of extrication of the arch from beneath the soil to a man thrown down on his hands and knees, at the same time to one side, by a load of hay falling upon him. He would first endeavor to get his arched back upright, wriggling at the same time in all directions to free himself a little from the surrounding pressure; and this may represent the combined effects of apogeotropism and circumnutation. The man, still wriggling, would then raise his arched back as high as he could; as soon as the man felt himself at all free, he would raise the upper part of his body, while still on his knees and still wriggling. This will represent the bowing backward of the basal leg of the arch, which aids in the withdrawal of the cotyledons from the buried and ruptured seed coats.

COTYLEDONS.—Cotyledons are in constant movement, chiefly in a vertical plane, and commonly rise up once and descend once in 24 hours; some move much oftener, thus those of *Ipomœa cærulea* moved thirteen times either upward or downward in 16h. 18m. As the motion when perfected gave ellipses, cotyledons may be said to circumnutate. In a large majority of instances observed by Mr. Darwin, the cotyledons sank a little downward in the forenoon, and rose a little in the afternoon or evening, thus exhibiting a certain periodicity in their movements, no doubt in connection with the daily alternations of light and darkness. When the cotyledons rise or fall to such a degree as to be vertical, or at an angle of at least 60° above or below the horizon, they are said to be asleep; the object gained being, as in leaves, to escape injury by radiation at night.

STEMS.—Several experiments with stems of plants of various orders showed that they continually circumnutate; and in the case of stem-climbers the circumnutation is of the most perfect kind.* An interesting modification of the process occurs in stolons or runners, which consist of much elongated flexible branches, that run along the surface of the ground and form roots at a distance from the parent plant; the circumnutation is so great in amplitude that it may almost be compared with that of climbing plants. The stolons are thus aided in passing over obstacles, and in winding between the stems of surrounding plants.

* For full description of twiners and other climbing plants, the reader is referred to Mr. Darwin's work on "The Movements and Habits of Climbing Plants." See also *Pop. Sci. Rev.*, vol. v., p. 55.



### EXPLANATION OF THE FIGURES.

*Figs.* 1, 2, 8–16, *after Darwin.*
*Figs.* 4–7, 19–22, *ad nat.*
*Figs.* 17, 18, *after Kerner.*

FIGS. 1 and 2. *Zea mays;* radicles excited to bend away from little squares of card attached to one side of their tips. In Fig. 2 the card has been rubbed off.

FIG. 3. A radish, of which the radicle had tied itself into a knot, probably in the same manner as in the case described and figured by Mr. Darwin, by the apex continually moving away from some obstruction until it had passed through the loop, as seen in Fig. 2. Reduced one-half.

FIG. 4. Pendulous head of florets of *Trifolium subterraneum;* the fertile flowers reflexed, the abortive still erect, forming a vertical cone.

FIG. 5. The same with abortive florets, now developed and becoming reflexed.

FIG. 6. A barren floret enlarged. It consists of the rigid "calyx-tube" supporting claw-like sepal globes.

FIG. 7. Multicellular hairs from the calyx, which exhibit aggregation under the process of absorption of nitrogenous matters. Figs. 4–7, enlarged.

FIG. 8. Leaf of *Averrhoa bilimbi* asleep, with its leaflets pendulous; much reduced.

FIG. 9. Leaf of *Lupinus pilosus* seen vertically from above, by day.

FIG. 10. Leaf of the same seen laterally, at night. Figs. 9 and 10 reduced.

FIG. 11. Leaf of *Melilotus officinalis*, during daytime.

FIG. 12. Leaf of the same asleep.

FIG. 13. Leaf of same asleep, seen vertically from above. Figs. 11–13 enlarged.

FIG. 14. Leaf of *Trifolium repens*, during the day.

FIG. 15. Leaf of same asleep, at night.

FIG. 16. Leaf of *Coronilla rosea* asleep, with its leaflets thrown upward.

FIG. 17. Flower of *Silene nutans* by night, the petals unrolled.

FIG. 18. The same by day, the petals being rolled up.

FIG. 19. Flower of oak-leafed *Pelargonium*, to show the position of the stamens *before* fertilization. The style and stigmas immature.

FIG. 20. The same, with filaments reflexed *after* fertilization; the anthers have fallen. The stigmas are now in the position of the anthers.

FIG. 21. Flower of *Teucrium scorodonia*, to show the position of the stamens *before* fertilization.

FIG. 22. Same after fertilization, the stamens having retired, while the stigmas now occupy their position.

## ILLUSTRATIONS OF PLANT MOVEMENTS.

* "The Power of Movement in Plants." By Charles Darwin, LL.D., F.R.S., assisted by Francis Darwin. 8vo. London: Murray. 1880.

† P. 2, 3. I have not here or elsewhere added inverted commas, for throughout this paper I have largely interwoven Mr Darwin's sentences with my own.

‡ The figure of the radish is not from Mr Darwin's work, but from a drawing made many years ago, and which would seem now to have received its explanation.

PEDUNCLES.—Flower stems form no exception to axial structures in the habit of circumnutating; but the effect is curiously modified by geotropism in the case of *Trifolium subterraneum*, and by apheliotropism in that of *Cyclamen persicum*, in both of which plants the object gained is the burying the unripe pods beneath the soil, leaves, etc. The flower-heads of *Trifolium subterraneum* produce but three or four perfect flowers at the base, all the other flowers above consisting only of cylindrical calyx-tubes with stiff spreading lobes, forming claw-like projections (Figs. 4–6). As soon as the perfect flowers wither, they bend back upon the peduncles. This movement is due to *epinasty*, a word coined to imply that the upper surface of an organ grows more quickly than the lower surface, and thus causes it to bend downward. While the perfect flowers are thus bending, the whole peduncle curves downward and increases much in length, even from 6 to 9 inches if necessary, until the flower-head reaches the ground At this period the younger, imperfect, central flowers are still pressed closely together, and form a rather rigid conical projection. The depth to which the flower-heads can penetrate varies from 0·25 to 0·06 inch. In the case of a plant kept in the house, a head partly buried itself in sand in six hours; with plants growing out-of-doors, Mr. Darwin believes that they bury themselves in a much shorter time. After the heads are buried, the central aborted flowers increase considerably in length and rigidity, and become bleached; they gradually curve, one after the other, upward or toward the peduncle (Fig. 5). In thus moving, the long claws on their summits carry with them some earth; hence a flower-head which has been buried for a sufficient time forms a rather large ball, the aborted flowers having caught up the earth with the claw-like sepal-lobes, act somewhat like the hands of a mole, which force the earth backward and the body forward.

The calyxes of all the flowers are clothed with simple and multicellular hairs (Fig. 7), which, on absorbing carbonate of ammonia presented to them, exhibited protoplasmic aggregation. As Mr. Darwin observes that only a few of the flower-heads, which from their position are not able to reach the ground and bury themselves, yield seeds, whereas the buried ones never failed to produce as many seeds as there had been perfect flowers, it may be reasonably conjectured that the object gained is to nourish the ripening seeds directly through their surfaces, and so to supplement root action. The capsules of cyclamen and of the wood sorrel *Oxalis acetosella*, are occasionally buried, but then only beneath dead leaves or moss.

LEAVES.—The movements of certain leaves which are said to sleep have long been observed, but it would seem that probably all leaves and cotyledons circumnutate, and that the so-called sleep is only a remarkable modification or development of this general kind of movement, accompanied, however, by other and often complicated motions. The seat of the movement generally lies in the petiole, but sometimes both in the petiole and blade, or in the blade alone. The movement is chiefly in a vertical plane; but as the ascending and descending lines never coincide, there is always some lateral movement, and thus irregular ellipses are formed. There is a periodicity in the movements of leaves, for they often or generally rise a little in the evening and early part of the night, and sink again on the following morning, this periodicity being determined by daily alternations of light and darkness, as already mentioned in the case of cotyledons. These periodic movements occur where there is no *pulvinus*, for where this is found, the movement is amplified into *nyctitropic*, or sleep movements.

Leaves, Mr. Darwin says, when they go to sleep move either upward or downward; or in the case of the leaflets of compound leaves, forward, that is, toward the apex of the leaf, or backward, that is, toward its base; or again, they may rotate on their own axis without moving either upward or downward; but in almost every case the plane of the blade is so placed as to stand nearly or quite vertically at night. Moreover, the upper surface of each leaf, and more especially of each leaflet, is often brought into close contact with that of the opposite one, as the upper surfaces appear to require more protection than the lower.

The nyctitropic movements of leaves and cotyledons are effected in two ways, first, by means of pulvini, which become ultimately more turgescent on opposite sides; and secondly, by increased growth along one side of the petiole or mid-rib, and then on the opposite side. This difference between the two means of movement consists chiefly in the turgescence of the cells of a fully-developed pulvinus not being followed by growth. The movements effected by growth on the alternate sides are confined to young growing leaves, while those effected by means of a pulvinus last for a long time.

The evil effects which result if sleeping leaflets be prevented from pressing their upper surfaces together, so as to protect them from radiation, were well seen in experiments of Mr. Darwin's, in which he pressed down the leaflets of *Oxalis*, *Marsilia*, etc., so that they could not bring their upper surfaces into contact; the result was that the leaves were killed. Thus of twenty-four leaves of *Marsilia* extended horizontally, exposed to the zenith and to unobstructed radiation, twenty were killed and one injured, while a relatively very small proportion of the leaves, which had been allowed to go to sleep with their leaflets vertically dependent were killed or injured. Mr. Darwin noticed that the difference in the amount of dew on the pinned open leaflets and on those which had gone to sleep, was generally conspicuous, the latter being sometimes absolutely dry, while the leaflets which had been horizontal were coated with large beads of dew. Another fact observable was that when leaves were kept motionless, they are more liable to injury than when they were slightly waved about by the wind, and thus got a little warmed by the surrounding air.

Cotyledons, as well as leaves, may sleep; the former seem to do so more commonly than leaves. Of 153 genera observed by Mr. Darwin, one or more species of twenty-six of these genera placed their cotyledons at night so as to stand vertically, having generally moved through an angle of at least 60°. In a large majority of genera the movement is a rising one. In all the species of *Oxalis* observed by Mr. Darwin, the cotyledons are provided with a pulvinus; and he adds that this organ has become more or less rudimentary in *O. corniculata*, in which the amount of upward movement of the cotyledons at night is very variable, but never enough to be called sleep. Similarly, in the Leguminosæ, all the cotyledons which sleep have pulvini. As this organ has been referred to several times, it will be as well to describe it. It constitutes a cushion or joint, and consists of a mass of small cells, usually of a pale color in the case of that attached to cotyledons from the absence of chlorophyl, and having a convex outline. The development of a pulvinus follows from the growth of the cells over a small defined space of the petiole being almost arrested at an early stage. As a pulvinus is formed by this arrestment of the growth of its cells, movements dependent on their action may be long continued without any increase in length of the part thus provided; and such long continued movements seem to be one chief end gained by the developement of a pulvinus.

It will be desirable now to give a few illustrations of nyctitropic movements from Mr. Darwin's observations.

*Averrhoa bilimbi* (Fig. 8).—The leaflets of this plant move spontaneously in a very marked manner during the day, are sensitive to touch, and sleep at night, when the leaflets hang vertically down and motionless.

*Lupinus*.—The digitate leaves of this genus sleep in three different ways. One of the simplest is that all the leaflets become steeply inclined downward at night, having been horizontal during the day, as those of *L. pilosus* (Figs. 9, 10), when asleep are often inclined at an angle of 50° beneath the horizon. In *L. hartwegii* and *L. luteus*, the leaflets, instead of moving downward, rise at night, forming a hollow cone with moderately steep sides.

With several other species, the position is remarkable. On the same leaf the shorter leaflets, which generally face the center of the plant, sink at night, while the longer ones on the opposite side rise, the intermediate and lateral ones merely twisting on their own axis; the result is that all the leaflets on the same leaf stand at night more or less inclined, or even quite erect, forming a vertical star.

*Melilotus*.—The species in this genus sleep in a curious fashion. The three leaflets of each leaf twist through an angle of 90°, so that their blades stand vertically at night, with an edge presented to the zenith; the two lateral leaflets always twist so that their upper surfaces are directed toward the terminal leaflet. This latter leaflet moves in another and more remarkable manner, for while its blade is twisting and becoming vertical, the whole leaflet bends to one side, and invariably to the side toward which its upper surface is directed; so that if this surface faces, say, the west, the whole leaflet bends to the west, until it comes into contact with the upper and vertical surface of the western lateral leaflet. Thus the upper surface of the terminal and of one of the two lateral leaflets is well protected. It may be added that the petioles and sub-petioles continually circumnutate during the whole twenty-four hours. (Figs. 11, 12, 13.)

*Trifolium repens*.—During the day, the leaflets of this plant are expanded horizontally (Fig. 14), but at night the two lateral leaflets twist and approach each other until their upper surfaces come into contact; at the same time they bend downward in a plane at right angles to that of their former position, until their mid-ribs form an angle of about 45° with the upper part of the petiole, this change of position requiring a considerable amount of torsion in the pulvinus. The terminal leaflet merely rises up without any twisting, and bends over until it rests on and forms a roof over the edges of the now vertical lateral leaflets (Fig. 15).

*Coronilla rosea*.—This plant affords an instance of leaflets rising at night from having been horizontal during the day. The leaflets at the same time bend backward toward the base of the petiole, until their mid-ribs form with it angles of from 40° to 50° in a vertical plane (Fig. 16).

*Cassia*.—The nyctitropic movements of the leaves in many species of Cassia are highly complex. Mr. Darwin's observations were made chiefly on *C. floribunda* and *corymbosa*, and he furnishes the following description. The horizontally extended leaflets sink down vertically at night, but not simply, as in so many other genera, for each leaflet rotates on its own axis, so that its lower surface faces outward. The upper surfaces of the opposite leaflets are thus brought into contact with one another beneath the petiole, and are well protected, as shown in the woodcut.* The rotation and other movements are effected by means of a well developed pulvinus at the base of each leaflet, as could be plainly seen when a straight, narrow black line had been painted along it during the day. The two terminal leaflets in the daytime include rather less than a right angle, but their divergence increases greatly while they sink downward and rotate, so that they stand laterally at night, as may be seen in the figure; moreover, they move somewhat backward, so as to point toward the base of the petiole. In one instance Mr. Darwin found that the mid-rib of a terminal leaflet formed at night an angle of 36°, with a line dropped perpendicularly from the end of the petiole. The second pair of leaflets likewise moves a little backward, but less than the terminal pair; and the third pair moves vertically downward, or even a little forward. Thus all the leaflets in those species which bear only three or four pairs, tend to form a single packet, with their upper surfaces in contact and their lower surfaces turned outward. Lastly, the main petiole rises at night, but with leaves of different ages to very different degrees; thus some rose through an angle of only 12°, and others as much as 41°.

The influence of light upon the movements of plants is various. Thus the so-called heliotropic movements are determined by the direction of the light, while periodic movements are affected by changes in its intensity. On the other hand apheliotropism implies that a plant bends from the light, a rare phenomenon, at least in a well marked degree. Parts of plants under the influence of diaheliotropism place themselves more or less transversely to the direction whence the light proceeds, and are thus fully illuminated. Lastly, some leaves rise or sink or twist so as to avoid great intensity of light. Such a phenomenon, Mr. Darwin suggests, should be called parheliotropic. All these movements consist of modified circumnutation. Space forbids a detailed description of these effects; but one curious result of Mr. Darwin's investigation is worth recording, and that is the transmitted effects of light. When, for example, the cotyledon of *Phalaris canariensis* is exposed to light, the upper part bends first, and afterwards the bending gradually extends to the base, and even a little below the ground. By protecting the whole upper half of the cotyledon from light, the lower part, though fully exposed to light, was prevented from becoming curved. Hence it is to be concluded that when seedlings are freely exposed to a lateral light, some influence is transmitted from the upper to the lower part, causing the latter to bend.

FLOWERS.—There are many instances of the various parts of flowers moving under the influence of stimuli; but the immediate causes in the different cases have not been so thoroughly investigated as by Mr. Darwin in the case of the vegetative organs, and at present, therefore, but little can be said beyond the fact that they do move. Thus, commencing with bracts, it may easily be seen how the erect bracts of the involucre of the dandelion become reflexed as soon as the fruit is ripened, thus allowing the parachute-like achenes to escape easily Moving corollas are very numerous. A large series of plants might be mentioned of which the corollas close up, either as soon as the sun is obscured, as *Mesembryanthemum*, *Anagallis arvensis*, *Convolvulus*, etc., or else at evening, such as many Compositæ, including the Daisy and Dandelion, re expanding on the return of light. Conversely, some night-flowering plants unfurl their petals only at night, coiling them up by day. As an illustration *Silene nutans* may be taken, concerning which Dr. Kerner tells us† that a flower lasts three days and three nights; with the approach of dusk the bifid limbs of the petals spread out with a flat surface, and fall back upon the calyx. In this position they remain through the night; curling themselves up into an incurved spire and becoming longitudinally creased at the same time on the return of sunlight and a warm temperature. No sooner does evening return than the wrinkles disappear, the petals become smooth, uncurl themselves, and falling back against the calyx, the corolla is again expanded (Figs. 17, 18).

In the Pea family, or Leguminosæ, there are several instances of the corolla having a power to move when irritated. Thus in the genera *Genista* and *Indigo*, the claws of the petals act like springs kept in a state of tension; for when the corolla is touched, as by an insect in search of honey, the claws suddenly curl downward, and the petals consequently drop vertically, while the stamens previously concealed within the keel petals, are violently thrown upward, showering the bee with pollen.†

The movement of stamens is perhaps more curious, and apparently intimately connected with the phenomenon of insect fertilization. As an example of slow movement, *Parnassia palustris* may be mentioned. In this flower each stamen in succession rises up, places the anther on the stigma, and having shed its pollen, retires and falls back upon the petals. Each stamen occupies about twenty-four hours in rising up and discharging its pollen, and takes about the same time to recede, the whole period being eight

*Cassia corymbosa*, during the day; and the same, asleep, at night.

* I am indebted to the courtesy of Mr. Darwin for the loan of the blocks for these figures

* "Flowers and their Unbidden Guests," p. 132

† *Journ. of Linn. Soc.*, vol. IX., p. 355, and vol. X., p. 488.

days, but varying according to circumstances of temperature, moisture, etc.*

*Berberis* furnishes an instance of rapid motion; for if the stamens be touched at the base of the filament, they instantly spring forward and strike the stigma, having previously lain on the surface of the spreading petals. The effects of the irritation on the filament of *Berberis* have been observed and described by M. E. Heckel.† It appears that the cells of the irritable part are arranged in a parallel manner (the back of the filament being insensible). Their contents are yellow and disseminated throughout the cavity. After irritation they undergo aggregation and contract into the center of the cell, and the cell wall is striated transversely. The cells of the back of the filament are contracted in repose, but extended in irritation.

The stamens of the common Lucerne, *Medicago sativa*, as also of other species of that genus, suddenly curve upward and remain rigidly fixed in an arched condition, having been previously horizontal.‡

Mr. Darwin has described numerous instances in the family Orchidaceæ, in which the *pollinia*, as of the common *Orchis mascula* and others, or of *Catasetum*, etc., have remarkable powers of movement; in the former cases slow, but in the latter rapid. In every case there is discernible some special adaptation to the fertilization of the flowers by insect aid.§

*Stylidium* affords another illustration of rapid motion. In this flower the stamens and style are consolidated into a column, which is curiously bent and hangs over one side of the flower. If it be touched near the base, it instantly flies over to the other side. A very similar motion occurs in the pistil of *Maranta*.

Some flowers have the stamens in a certain position on first expanding, but they take up another position subsequently. This I found to be the case with *Alisma plantago*. On first expanding the stamens spread out, their anthers being extrorse, but afterward they curl backward over the stigmas, thereby in all probability effecting self fertilization. In several flowers of different species the filaments retire after the anthers have shed the pollen or fallen off, as in the lemon-scented and oak-leafed *Pelargoniums*, and in *Teucrium scorodonia*, or wood-sage. In both of these the anthers mature some time before the stigmas, and assume a position adapted to insects to transport their pollen. Subsequently the filaments bend away, and the styles now take up the same position that the filaments had previously held (Figs. 19–22).

Space will not allow further descriptions, but enough has now been said to show how extensive and varied are the movements effected by the different organs of plants, and the advantages accruing to them by possessing such powers of motion.—*Popular Science Review.*

## ON THE DISPOSITION OF COLOR MARKINGS OF DOMESTIC ANIMALS.

By WM. H. BREWER, Professor of Agriculture in Yale College.‖

FOR some years I have been making and recording observations on the color-markings of domestic animals, and read a paper before the Connecticut Academy of Sciences, "On the Foot-markings of Horses," and another, "On the Color-markings of Domestic Animals and their Relations to those of Wild Animals." The present paper is but a further extension of the same subject, and is offered at this time in the hope that I may get suggestions from other observers, as well as to publish before this body facts which have had a merely limited publication before. The tables upon which the conclusions are based will be published at another time.

It is common for horses of otherwise solid colors, particularly bays, browns, blacks, and others with dark-colored legs, to have one or more of the legs above the hoof marked with white; a white ring or stocking extending a greater or less distance up the leg and ending suddenly. More rarely it is a mere blotch, and when thus restricted it is oftenest on the back side of the leg. The hoof may or may not be white, but is liable to be white if there is a white stocking above it.

Observations made in several different States, and extending to several thousands of foot-marked horses, show that *more of the white feet are on the left side than on the right.*

There are fifteen ways in which the four feet may be marked, the sixteenth being no white feet. The left hind foot is the one most often white and the right fore foot the least often, the order of frequency of white feet being the left hind, the right hind, the left fore, the right fore. If but one foot is white it is oftenest on the left side.

If three feet are white, two of them are oftenest on the left side.

If two feet on one side and none on the other are white, then these two are oftenest on the left side. The relative frequency of each, and of each combination, as well as the percentage found with the various colored horses, with other data relative to color, will be given at another time, as I have not had the time to prepare the tables for this meeting.

The hind feet are much oftener marked than the fore, and if we examine cases where only the two hind feet are white, in a majority of cases the amount of white on the left is the greater, the white extending farther up the leg. This is probably also true where only the two fore feet are marked, but that is such a rare marking that I cannot make this generalization from actual observation. And here let me say that, in the distribution of white feet, some combinations are so rare that it would be an important datum in the identification of stolen or lost horses, the percentage of horses of any one color having, say, only the right fore foot or the two fore feet marked, is very small.

Observations on spotted horses show that a majority have more white on the left than on the right side.

This shows itself in two ways. In the first place, if there is merely a white spot on the horse (other than on the face or just above the hoof), then it is oftenest on the left side.

In the second place, if the horses are decidedly spotted (calico horses, or pintos), then the area of white, so far as could be judged by the eye, is largest on the left side in a majority of cases. Formerly spotted horses were fashionable, as they still are among semi-barbarous peoples, among Indians, and on particular ranches in the far West, but now they are so unfashionable in the older States that it is not easy to find a sufficiently large number of cases for extensive generalization, but, so far as observed, a majority are as stated. I have not included in this those cases where several such horses came from the same ranch, and where a similarity of marking might be the result of family heredity.

I think, therefore, that I have proved that, as regards horses with white marks or spots, these are most often found on the left side, and also that the quantity of white is greatest on that side.

Mules are rarely spotted, although it sometimes occurs, and are specially bred in some places, but I have never seen a foot-marked mule; that is, a mule with otherwise solid colors but with a white foot or stocking, as horses have. Spotted mules may have white legs and feet.

As to horned cattle, the data are less satisfactory. In the first place they are not foot-marked as horses are, but in quite another way. If white occurs it is in blotches and patches, these most often, I think, on the front side of the leg, not extending to the hoofs, and not in a clean, well-defined white ring or stocking, as is common with horses. Moreover, at agricultural fairs and similar places where we see many breeds exhibited together, the results are usually vitiated, because of the families or strains exhibited together.

However, so far as my observations go, they point in the same direction, and I strongly suspect that the same law holds true with cattle that I have proved to be true with horses, although my observations are too few to establish it on large numerical data.

The same may be said of dogs, but here the disposition of marked feet has no value, because white feet is a fancy "point" which is bred to in some breeds. If the right and left are shown in dogs by color, I have not been able to verify it, but it is strongly shown by the tail, if not by color, in the vast majority of cases the tail being carried on the left side. With some breeds this has long been a character, and even in breeds where this is not a "point" it is usually true. It is not true, however, that dogs which carry the tail to the left are not afflicted with rabies, as has often been affirmed.

With swine as with dogs, the disposition of white feet has no value in this discussion, because with some breeds (as in the Berkshires) it is a fancy point bred to, and I have not carried my observations to the relative areas of white on the two sides of spotted hogs in a sufficiently large number of cases to generalize, but enough, however, to induce suspicions that the rule holds good here too.*

From the observations made on the disposition of color, it seems to me probable that, with all our spotted domestic animals, white appears more frequently and in larger quantity on the left side.

And if in domestic animals, why not in wild animals? Of these, except in the few cases seen in menageries and stuffed skins in museums—all too few for any generalization, but yet indicating that way—I have no data of value, except with skunks. As is well known, these vary much as to white, and in the skins I have examined the majority had most white on the left side, but the number was too small (only about sixty) to base generalizations upon.

As the result of a long investigation (by no means finished), I very strongly suspect this is a law of nature, and that as color is one of the characters (in vertebrates) most sensitive to various influences, it is the first to show a tendency of difference between the right and left side, which culminates in the right-handedness of man.†

As white color is often found correlated with certain physical weakness, it early suggested itself to me that the predominance of white on the left side was an indication that that was physically the weaker side, and the same thing has been suggested by several persons to whom I have told my observations.

The relation of the color-markings of domestic animals to bilateral symmetry has been the subject of discussion, the statement having been reiterated in various shapes and ways, that wild animals are similarly marked (if marked at all) on both sides, whereas with domestic animals the rule is that there is no such symmetry.

My own belief, founded on numerous observations on various kinds of domestic animals, is that there is no such difference, and that the difference is one of degree and not of kind. The disposition and kind of the color-markings of wild animals is doubtless related to protection and to ornament, and both of these would apply to both sides alike. If there is any reason why markings or dispositions of color on one side are either protective or ornamental, these reasons are equally strong for the other side, and so we might expect to find bilateral symmetry even more perfect than it really is, for the symmetry assumed is general rather than special. I have examined many skins of marked animals, tigers, leopards, cougars, and other species of the cat family, as well as zebras, in fact *all* the skins of marked animals to which I have had access, and I find the symmetry is never absolute in the details. The markings of the two sides resemble each other strongly in a general way, but when examined spot for spot, stripe by stripe, they will be found to vary in every character except the most general, not only between different animals, but the two sides of the same animal. This is true even of spotted serpents.

With our larger wild animals, if spots occur, as they often do by sporting, they make the creature conspicuous to its enemies, they are the reverse of protective, and they are thus quickly eliminated from the herd. Not so with domestic animals; irregular spots are marks facilitating recognition, and have a value often in proving ownership, and thus become protective.

Spots irregularly disposed on domestic animals have had a protective value among partially civilized people since the days of Jacob certainly, and probably much longer.

But with our modern breeders fashion largely decides this. In breeds where markings are a "point" in breeding they are symmetrically disposed, as are the white feet on Newfoundland dogs or Berkshire pigs, the broad white belt on the "sheeted breed" of cattle, and other breeds that regularly suggest themselves. In all such cases the markings are as symmetrical in a general way as with wild animals where the selection has been directed by nature, and even more so than in the skunk.

If they are not breeder's points, then they are not protective, and are as irregular as are the sportive colorings sometimes found in wild animals. The spotted bears and buffaloes (sports) occasionally seen are as irregularly marked as are the cows of our herds or the calico horses occasionally seen in our streets. Moreover, with the spotted breeds, even if the colors are irregularly disposed, there is a tendency toward symmetry in a majority of cases, as is easily proved by comparing the markings of the two sides, the feet, the lines on the back, etc., on any breed of spotted cattle at any agricultural fair, and even on calico horses. If a number of cases are observed, the color is found to be usually disposed as if there was an effort toward bilateral symmetry, if one examines them in detail spot by spot, over back, sides, about eyes, ears, legs, and face.

Each of the points of this paper I purpose to elaborate more in detail at some future time.

* Baxter's "British Flora," vol. i. p. (70)

† *Bull. Soc. Bot. Fr.*, 1874, vol. xxi., p. 308.

‡ *Journ. of Linn. Soc.*, vol. ix., p. 397.

§ See Fertilization of Orchids.

‖ Read before the American Association, Cincinnati, Ohio, August, 1881.

* Unlike the dog, the curl of the pig's tail is as often on one side as on the other, and the same animal may be carried on either side, according to the taste or fancy of the wearer.

† We frequently see statements floating on the literature of the day, relative to the right-handedness of animals being indicated by horses stepping the right foot first, elephants using the left tusk by preference, and a number of other statements of a similar character; but so far as I have been able to observe, I have not found one of these to be borne out by fact.

## RABBITS AND GOATS NEAR THE SOUTH POLE.

MR. E. J. CHIPMAN, mate of the whaler Pilot's Bride, who has just returned from a voyage to the Antarctic Ocean, says the forty pairs of rabbits and the twelve goats that were taken from Capetown to Kerguelen in 1875 have thrived wonderfully, the island fairly swarming with rabbits, while the goats number some hundreds. Teal duck are found about the island in large flocks, and what with roast kid and duck, and stewed rabbit, and plenty of Kerguelen cabbage, Captain Fuller's crew of twenty-eight men had an agreeable change in their diet while there.

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